

Apollo-Moon
Bookbinders
Tel: (03) 9836 1800

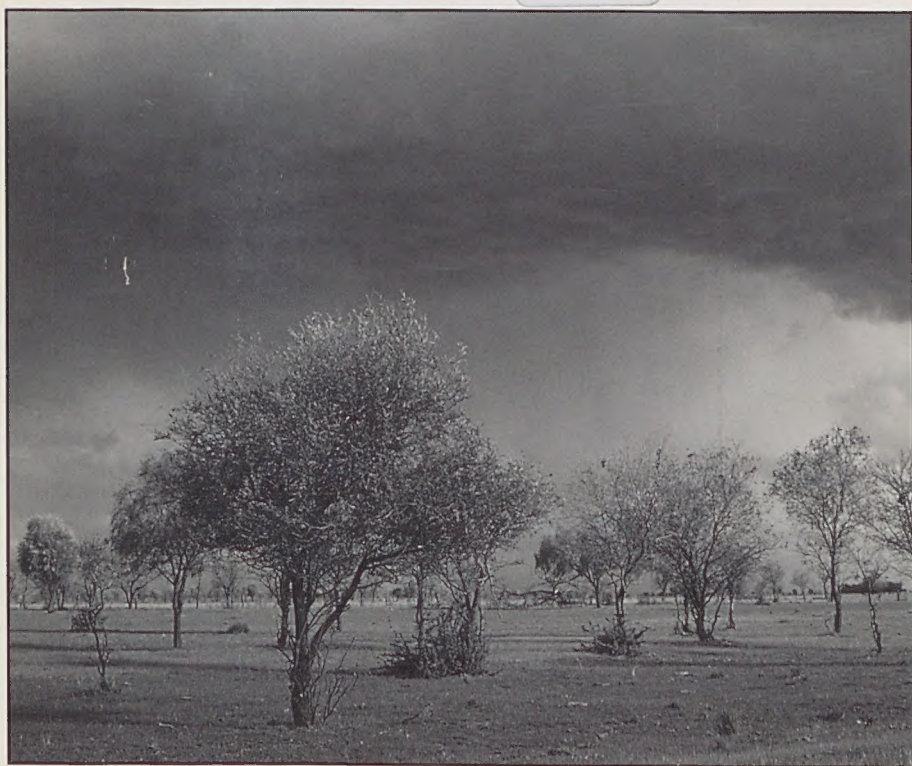




CUNNINGHAMIA

A journal of plant ecology

copy 1
LIBRARY



Volume 3(1) • 1993

ROYAL BOTANIC GARDENS SYDNEY
National Herbarium of New South Wales



Cunninghamia is published by the National Herbarium of New South Wales, Royal Botanic Gardens Sydney. It covers all aspects of plant ecology, in particular vegetation survey and mapping, and plant community dynamics. It deals primarily with New South Wales.

Cunninghamia is published annually in July.

Annual subscription

Within Australia

Individuals \$15

Institutions \$30

Overseas

Individuals and institutions, **air mail** A\$35

Subscription details, with a cheque or money order made out to the Royal Botanic Gardens Sydney, should be sent to:

The Finance Officer
Royal Botanic Gardens
Mrs Macquaries Road
Sydney, NSW, Australia 2000

Cover

Acacia pendula (Boree) woodland north-east of Deniliquin. (See Hay Plain vegetation paper pp. 1-122).

Photographer: Marianne F. Porteners

CUNNINGHAMIA

A journal of plant ecology

Royal Botanic Gardens
and National Herbarium

16 AUG 1993

LIBRARY

Volume 3(1) • 1993

CONTENTS

- The natural vegetation of the Hay Plain: Booligal-Hay and
Deniliquin-Bendigo 1:250 000 maps **Marianne F. Porteners** 1
- The distribution, abundance and habitat of *Eucalyptus dunnii*
(Myrtaceae) (Dunn's White Gum) in New South Wales
J.S. Benson and T.C. Hager 123
- Prediction of the habitat for *Tetratheca juncea* in the Munmorah
area, near Wyong, New South Wales **R.J. Payne** 147
- Vegetation of Mulligans Flat, A.C.T. **B.J. Lepschi** 155
- Floristic lists of New South Wales (IV) **D.H. Benson and S.C. Melrose** 167
- Bryophytes of the Royal Botanic Gardens, Government House and
the Domain, Sydney
H.P. Ramsay, R.G. Coveny, E.A. Brown and A.K. Brooks 215
- Mangrove, saltmarsh and peripheral vegetation of Jervis Bay
Peter J. Clarke 231
- REVIEW
- Vegetation survey and mapping in Queensland **J.S. Benson** 255



CUNNINGHAMIA 3(1): 1-256 • JULY 1993

Scientific Editor

Doug Benson

General and Production Editor

Sarah Dinning

Production Assistant

Lydia Alvarez

Editor of Publications

Gary Bridle

Other members of Editorial Committee

Barbara Briggs, John Benson, Ken Hill

Printer

Ambassador Press Pty Limited

ISSN 0727-9620

National Herbarium of New South Wales
Royal Botanic Gardens Sydney
Mrs Macquaries Road
Sydney, NSW, Australia 2000

CUNNINGHAMIA

A journal of plant ecology

Volume 3(2) • 1993

Copy 1

Ecology of Sydney Plant Species Part 1

Ferns, fern-allies, cycads, conifers and dicotyledon families
Acanthaceae to Asclepiadaceae

Doug Benson and Lyn McDougall

CONTENTS

Introduction	257
Map of the Sydney region	263
Ferns and fern allies	265
Cycads	336
Conifers	339
Flowering plants: dicotyledon families Acanthaceae to Asclepiadaceae	344
References	412
Index to plant families and species	416

Royal Botanic Gardens
and National Herbarium

10 JAN 1994

LIBRARY



CUNNINGHAMIA 3(2): 257-422 • DECEMBER 1993

Scientific Editor

Doug Benson

General and Production Editor

Margaret Metz

Typesetting and production

Lyn McDougall

Editor of Publications

Gary Bridle

Other members of Editorial Committee

Barbara Briggs, John Benson, Ken Hill

ISSN 0727-9620

National Herbarium of New South Wales

Royal Botanic Gardens Sydney

Mrs Macquaries Road

Sydney, NSW, Australia 2000

CUNNINGHAMIA

Royal Botanic Gardens
and National Herbarium

A journal of plant ecology

Volume 3(3) • 1994

- 1 SEP 1994

LIBRARY

CONTENTS

- The natural vegetation of north-western New South Wales: notes to accompany the 1: 1 000 000 vegetation map sheet
John Pickard and E.H. Norris 423
- Rainforest stands between Barrington Tops and the Hunter River, New South Wales
J.C. Turner and S.L. Vernon 465
- Observations on the effects of mowing on native species in remnant bushland, western Sydney
T.A. James 515
- The effect of time since fire on the cover and composition of cryptogamic soil crusts on a eucalypt shrubland soil
D.J. Eldridge and R.A. Bradstock 521
- Lost and found: *Nothofagus moorei* at Comboyne
C.L. Bale and J.B. Williams 529
- Observations on the ecology and conservation status of the rare herb *Gentiana wingecarribiensis*
P.G. Kodela, T.A. James and P.D. Hind 535
- Floristics, structure and diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney
David Keith 543
- Performance of halophytes from semi-arid areas on two saline seepage scalds of the Central West Slopes of NSW
W.S. Semple and D. Waterhouse 595
- The native grasslands of the Monaro region: Southern Tablelands of NSW
J.S. Benson 609
- Plant communities of the Monaro lakes
J.S. Benson and S.W.L. Jacobs 651



CUNNINGHAMIA 3(3): 423-676 • JULY 1994

Plant ecology 1969-1994

This issue of Cunninghamia marks 25 years of ecological research at the National Herbarium of New South Wales, Royal Botanic Gardens Sydney. During this time there has been an increasing demand for information on plant communities and flora, a knowledge of which is essential for long-term sustainable management of our diverse natural environment and biota. Major vegetation surveys in the Sydney area, western and south-western New South Wales and Lord Howe Island have been directed towards meeting this need. Focal areas such as Terania Creek and Washpool forests have called for specific vegetation reports.

Current ecological work includes major map projects for Sydney, the New England area, and the south-west of the State, while an increasing demand for species information is being met by the Ecology of Sydney Plant Species project. This will provide biological and ecological information on each of the 3 000 plant species in the Sydney Basin.

ISSN 0727-9620

National Herbarium of New South Wales
Royal Botanic Gardens Sydney
Mrs Macquaries Road
Sydney, NSW Australia 2000

CUNNINGHAMIA

A journal of plant ecology

Royal Botanic Gardens
and National Herbarium

Volume 3(4) • 1994

27 FEB 1995

LIBRARY

CONTENTS

The natural vegetation of the Sydney 1:100 000 map sheet

Doug Benson and Jocelyn Howell

Introduction	677
Description of map units	
Map unit 4a – Estuarine Complex	689
Map Unit 6b – Blue Gum High Forest	690
Map Unit 6c – Glen Forest	691
Map Unit 9d – Transition Forest	693
Map unit 9g – Spotted Gum–Blackbutt Forest	695
Map unit 9h – Narrabeen Slopes Forest	696
Map unit 9o – Turpentine–Ironbark Forest	697
Map unit 9sf – Duffys Forest	699
Map unit 9t – Coastal Dune Forest	700
Map unit 10ag – Sydney Sandstone Gully Forest	701
Map unit 10ar – Sydney Sandstone Ridgeline Woodland	703
Map unit 21a – Coastal Clay Heath	705
Map Unit 21b – Coastal Dune Heath	706
Map Unit 21g – Coastal Sandstone Heath	707
Map unit 27a – Coastal Swamp Forest Complex	711
Map Unit 28c – Coastal Freshwater Swamp	711
Major conservation areas	
Angophora Reserve and Hudson Park	712
Barrenjoey Head	713
Berowra Valley Bushland	714
Bicentennial Park – Homebush Bay	714
Botany Bay National Park – La Perouse	714
Bouddi National Park	715
Brisbane Water National Park	715
Cooks River – Wolli Creek	717
Cumberland and Darling Mills State Forests	718
Dalrymple–Hay Nature Reserve	718

Garigal National Park – Deep Creek	719
Garigal National Park – Davidson	720
Georges River National Park	720
Katandra Bushland Sanctuary	720
Ku-ring-gai Chase National Park	721
Lane Cove River National Park	724
Lion Island Nature Reserve	725
Long Island Nature Reserve	726
Manly–Warringah War Memorial Park	726
Marramarra National Park	727
Muogamarra Nature Reserve	728
Spectacle Island Nature Reserve	729
Sydney Harbour National Park	729
Wallumatta Nature Reserve	729

Ecology of Sydney plant species

Part 2: Dicotyledon families Asteraceae to Buddlejaceae

Doug Benson and Lyn McDougall

Introduction	789
Families	
Asteraceae	800
Avicenniaceae	948
Balsaminaceae	949
Basellaceae	949
Baueraceae	950
Berberidaceae	952
Bignoniaceae	953
Boraginaceae	956
Brassicaceae	967
Buddlejaceae	994
Index	996

The natural vegetation of the Hay Plain: Booligal–Hay and Deniliquin–Bendigo 1:250 000 maps

Marianne F. Porteners

Abstract

Porteners, Marianne F., (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1993. *The natural vegetation of the Hay Plain: Booligal–Hay and Deniliquin–Bendigo 1:250 000 maps*. *Cunninghamia* 3(1): 1–122. The composition and extent of the present native vegetation, both remnant and modified, covered by the following 1:250 000 map sheets is described and mapped from aerial photography and field traverses: Booligal (33°00'S to 34°00'S, 144°00'E to 145°30'E), Hay (34°00'S to 35°00'S, 144°00'E to 145°30'E) and Deniliquin–Bendigo (35°00'S to the Murray River, 144°00'E to 145°30'E). The Hay Plain is situated in south-western New South Wales and is covered by the South Western Plains botanical subdivision. The term Hay Plain is used to refer to that area of the riverine plain covered by these maps. In its wider context it refers to the whole of the riverine plain, comprising the extensive alluvial deposits of the Murray River and its major tributaries, the Murrumbidgee and Lachlan Rivers. The characteristic landscape is an alluvial plain with a westerly to northerly transition to aeolian landforms. Twenty-one vegetation communities occurring within the mapped area are described. These include saltbush (*Atriplex* spp.) and bluebush (*Maireana* spp.) shrublands, perennial grasslands, woodlands of *Callitris* and Belah–Rosewood (*Casuarina pauper* and *Alectryon oleifolius*), riparian forest and mallee communities. Few undisturbed areas of natural vegetation remain due to over 150 years of extensive land use. The poor conservation status of many of the communities is discussed.

Introduction

'It is impossible for me to describe the kind of country we were now traversing, or the dreariness of the view it presented. The plains were still open to the horizon, but here and there a stunted gum-tree, or a gloomy cypress, seemed placed by nature as mourners over the surrounding desolation' (Charles Sturt 1833).

The Hay Plain in south-western New South Wales is an expansive alluvial plain dominated by chenopod shrublands and bisected by a network of wooded rivers and creeks. Known also as the saltbush plain it is considered by many to be a bleak and desolate place but to others it conjures up romantic images of Cobb and Co. coaches transporting mail and goods to lonely outposts; the solitary pub on the One Tree Plain and early settlers trying to make a living from marginal, inhospitable land. The landscape has been extensively modified over the past 150 years by European settlement. The saltbush plains have been heavily stocked with sheep and to a lesser extent with cattle and the more arable lands adjacent to the rivers have been cleared for cropping. Forests and woodlands of *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* still line the rivers and creeks and cover extensive floodplain areas. Relatively small areas remain of once-extensive *Callitris glaucophylla* and *Acacia pendula* woodlands, which were logged for building materials and fodder. Widespread dieback of *Atriplex vesicaria* has considerably reduced this once-dominant vegetation community. Little of the vegetation is represented in any conservation zone and few undisturbed areas exist today.

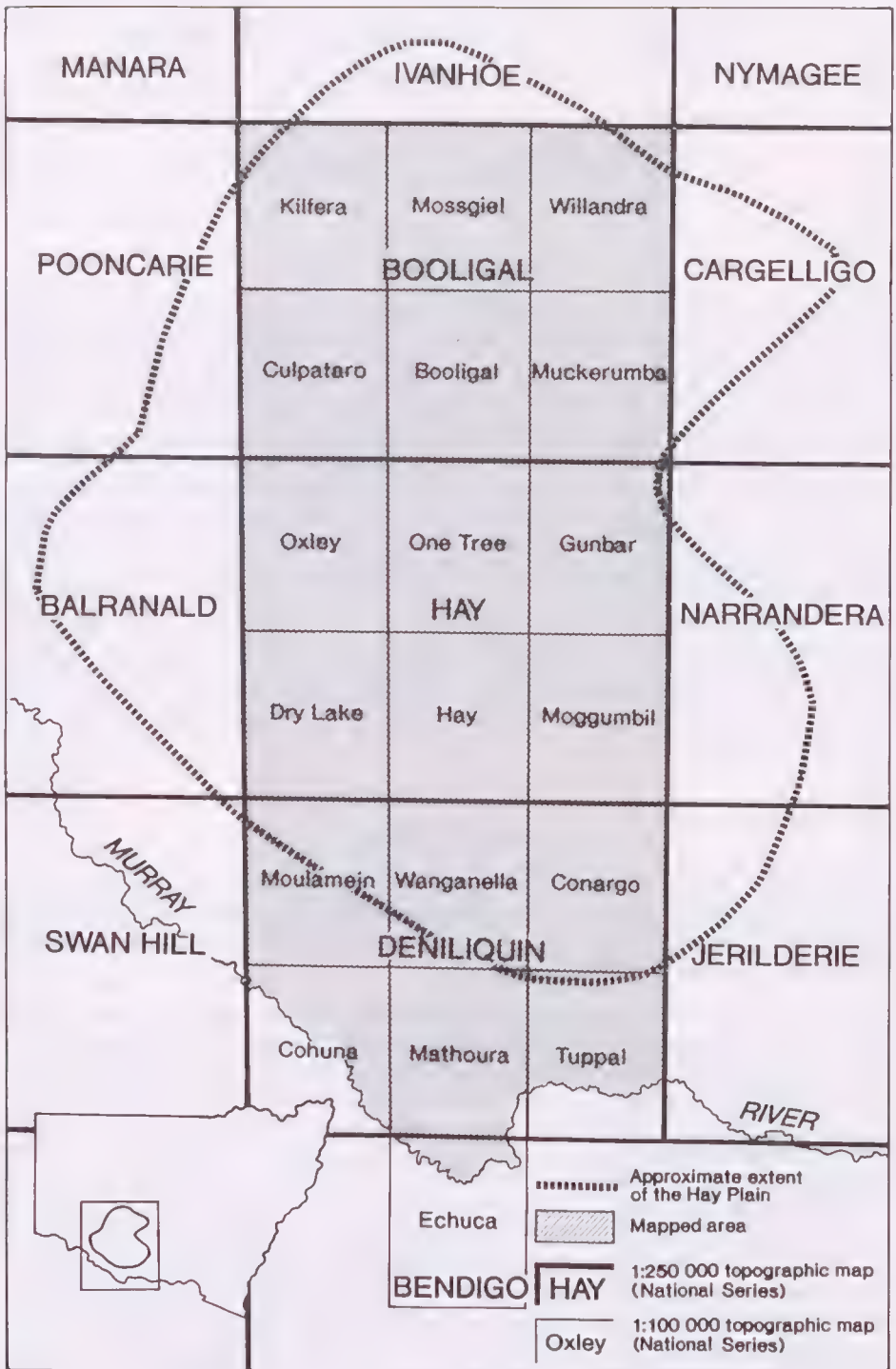


Figure 1. Locality map showing the extent of the Hay Plain in south-western New South Wales, and the associated map sheets.

Location

The Hay Plain in south-western New South Wales is covered by the Australian 1:250 000 Topographic Survey sheets Booligal, Hay and Deniliquin (SI 55-5, SI 55-9, SI 55-13) and a portion of the Bendigo Joint Operations Graphic (SJ 55-1) (Fig. 1). The term riverine plain has also been used to describe the larger area covering the whole alluvial plain across which the Murray and Murrumbidgee Rivers flow westward from the eastern highlands (Beadle 1948, Moore 1953, Butler 1950). Portions of the Hay Plain occur on the Cargelligo, Narrandera, Jerilderie and Balranald-Swan Hill 1:250 000 maps and many of the vegetation communities identified in the current survey extend to these areas. The Lowbidgee region, a low, very flat and relatively recent floodplain where the surface relief of palaeochannels has been obscured by more recent deposition, occurs further west between Maude and Balranald.

The total area mapped is 4 392 200 ha or almost 4.5 million ha. Each complete 1:250 000 map covers an area of 138 X 110 km (or 1 524 900 ha) and the New South Wales portion of the Deniliquin-Bendigo map covers an area of 1 342 400 ha. Much of the mapped area falls within the Central Division of New South Wales, where the land is under freehold tenure. North of the Lachlan River in the Western Division, most of the land is held under perpetual grazing lease with some areas of freehold country.

The major townships are Hay and Deniliquin with populations of 3000 and 7250 respectively (Fig. 2). Smaller towns from north to south include Mossgiel, Booligal, Oxley, Carrathool, Maude, Moulamein, Wanganella, Conargo, Barham, Mathoura and Moama. Just off the map but used for reference are Hillston to the east of the Booligal map and Ivanhoe to the north. Most of the mapped area falls under the Carrathool, Hay, Windouran, Conargo and Murray Shires with small portions in the Central Darling, Balranald, Murrumbidgee and Wakool Shires. The Sturt and Cobb Highways traverse the mapped area from east to west and north to south respectively. The Mid-western Highway enters the Hay map in the north-east from West Wyalong while the Riverina Highway similarly connects Deniliquin to towns further east. The now unused Junee-Hay railway line enters the map area from the east, terminating at Hay and a portion of the Sydney-Broken Hill line crosses in the far north-east of the Booligal map sheet.

The eastern boundary of the mapped area is at longitude 145°30'E which runs east of Roto, Gunbar, Carrathool, Four Corners and Conargo and west of Hillston and Tocumwal. The western boundary is at longitude 144°00'E which runs west of Ivanhoe, Oxley, Moulamein and Barham. The northern boundary runs almost parallel with the Sydney to Broken Hill railway line but south of Ivanhoe and Conoble siding, with Trida and Roto sidings and Warranary Hill within the mapped area in the east. The Murray River forms the southern boundary with the townships of Barham, Moama and Echuca (Vic.) on its banks.

The dominant features of the mapped area are the major rivers. The Murrumbidgee River runs east-west through the Hay map area, with the Lachlan River joining in the west at the Great Cumbung Swamp. The Murray River in the south defines the state border between New South Wales and Victoria at its southern bank. Its anabranch, the Edward River, traverses the Deniliquin map and rejoins the Murray to the west of the mapped area near Kyalite. Willandra Creek crosses the Booligal map in the north, terminating in the depressions of the Willandra Lakes system further west.

Climate

The general climate of the Hay Plain is semi-arid, with very hot summers, mild winters and a winter-dominant rainfall (Edwards 1979). The diurnal contrast is one of

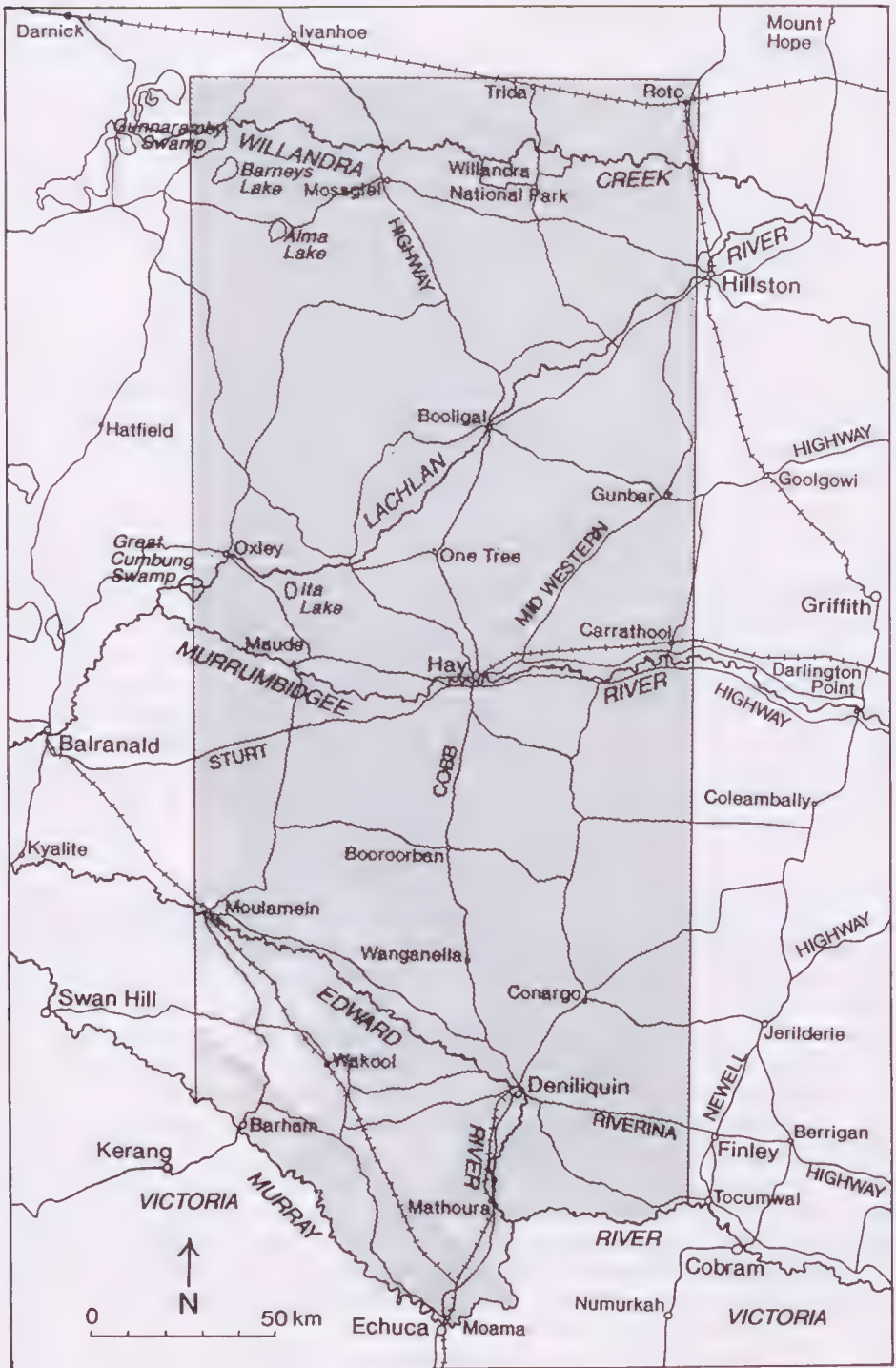


Figure 2. Major natural features and communications of the mapped area (Booligal-Hay and Deniliquin-Bendigo map areas shaded).

hot days and cool nights in summer and warm days and cold nights in winter. Dry years are common and often consecutive, resulting in prolonged periods of drought, often lasting several years. Topography does not exert a strong influence on the climate of the region, except for local restrictions and modifications of air flow. Most of the climatic variation is due to the wide longitudinal spread of the region (Bureau of Meteorology 1955). Climatic averages for Deniliquin, Hay and Ivanhoe (temperature and rainfall data) and Booligal and Mossiel (rainfall data only) are given in Table 1.

The hottest month is January when average daily temperatures range from 17.2–33.0°C at Hay while the lowest temperatures normally occur in July, with an average range of 3.6–14.8°C (Bureau of Meteorology 1988). Ivanhoe, at the far northern edge of the Plain experiences slightly hotter summer and cooler winter temperatures while temperatures in Deniliquin, in far south of the mapped area are slightly lower in summer and winter.

In south-western New South Wales, annual rainfall decreases from east to west with a predominantly winter dominance that increases towards the south. Further north, the rainfall decreases and is more evenly spread throughout the year. Correspondingly, evaporation increases from east to west. Summer rainfall is generally from localised thunderstorms, while the more reliable winter rains result from cold fronts associated with the passage of depressions across the southern ocean (Rhodes 1990). The average annual rainfall decreases from about 400 mm at Deniliquin to 300 mm at Ivanhoe in the far north-west. The peak winter rainfall for the Hay district is 240–360 mm (Edwards 1979).

Rainfall is most reliable during the months of July and August and the most variable during the January to March quarter. Rainfall variability increases in the north and west of the area. Evaporation is at its highest during the period of November to February. The June to September period is generally the most favourable for plant growth due to the higher winter rainfalls (Rhodes 1990). Dry periods are not unusual and approximately 29 drought years were experienced in western New South Wales between 1900 and 1986 (Dalton 1988).

Geology

The Hay Plain consists of two broad geological types: the fluvial plains comprising alluvial and lacustrine deposits of gravel, sand, silt and clay, and the aeolian landscape of flat to gently undulating plains and dunes of red clayey sands and loams (Semple 1990) (Fig. 3). Bedrock hills of Palaeozoic sediments mark the edge of the Murray Basin in the extreme north-east of the mapped area at Warranary Hill and on the Manfred Range in the central north (Norris & Thomas 1991). Low ranges and rocky outcrops to the east represent the boundary between outcropping Palaeozoic bedrock and the Tertiary/Quaternary alluvial plains (Norris & Thomas 1991). To the west the landscape becomes aeolian in character, marking the transition from riverine sediment sources in the east to marine and littoral sources from the west (Mabbutt 1980).

The Hay Plain lies within the Murray Basin which was formed during the Tertiary Period about 60 million years ago (Semple & Eldridge 1989). Active sedimentation followed by fluvial deposition by prior streams gave the present landscape its form (Pels 1969a). In the late Tertiary the western part of the Basin was covered by sea and extensive deposits of marine sands were laid down. This area, known as the Murra-vian Gulf, extended east to about Hatfield and north to half-way between Mildura and Menindee. The gulf regressed during the Pliocene and carbonates and clays were deposited in the early Quaternary when the western part of the region was again

Table 1. Climatic averages for Deniliquin, Hay and Ivanhoe (temperature and rainfall data) (Bureau of Meteorology 1988) and Booligal and Mossiel (rainfall data only) (National Climate Centre 1992).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Deniliquin (22 years of temperature record and 126 years of rainfall record)												
Daily max. temp. (°C)	31.5	31.8	27.8	22.8	18.1	14.8	13.9	16.0	18.7	22.7	26.4	29.4
Daily min. temp. (°C)	15.9	16.7	13.7	10.0	7.2	4.2	3.3	4.9	6.6	9.3	11.8	14.1
Rainfall (mm)												
Mean	29	28	33	32	40	41	35	37	38	40	28	28
Median	16	15	21	23	34	36	31	35	33	33	20	20
Mean no. raindays	4	3	4	5	7	9	9	9	8	7	5	4
Hay (29 years of temperature record and 106 years of rainfall record)												
Daily max.temp. (°C)	33.0	32.6	29.0	24.0	18.8	15.9	14.8	17.0	20.2	24.2	28.2	31.0
Daily min. temp. (°C)	17.2	17.2	14.6	10.6	7.4	4.6	3.6	5.0	6.9	10.1	12.8	15.3
Rainfall (mm)												
Mean	27	29	30	30	35	36	29	32	31	36	25	25
Median	13	16	21	22	30	32	25	28	27	28	17	15
Mean no. raindays	3	3	4	5	6	8	8	8	6	6	4	4

Booligal (rainfall statistics for the period 1891 to 1991 using all available data)

Rainfall (mm)												
Mean	26	22	32	26	34	32	27	28	25	31	24	24
Median	12	9	17	17	27	27	25	26	19	22	17	15
Mean no. raindays	3	3	3	3	5	6	7	6	5	5	4	3

Mossgiel (rainfall statistics for the period 1894 to 1978 using all available data)

Rainfall (mm)												
Mean	26	26	28	19	28	29	23	25	23	29	22	26
Median	11	11	14	12	20	21	16	21	16	19	16	14
Mean no. raindays	3	3	3	3	4	5	5	5	4	4	3	3

Ivanhoe (25 years of temperature record and 101 years of rainfall record)

Daily max. temp. (°C)	34.0	34.0	30.6	25.6	20.1	16.9	16.2	18.6	21.8	26.2	29.9	32.8
Daily min. temp. (°C)	17.9	18.2	15.0	10.5	6.9	3.9	3.2	5.0	7.2	11.1	13.8	16.4

Rainfall (mm)												
Mean	28	26	28	20	27	26	22	24	21	28	23	26
Median	10	11	16	11	21	23	17	20	16	20	13	13
Mean no. raindays	3	3	3	3	5	6	5	5	5	5	3	3



Figure 3. The geology of the mapped area. White unhatched areas indicate flat, alluvial and lacustrine deposits of clay, silt, sand and gravel. Hatched areas are largely aeolian, flat to gently undulating plains and dunes of red and red-brown clayey sands and loams. Spotted areas are sandstone-conglomerate sediments (slate and granite in the far south-east). Based on Goldbery and West (1968) and Offenbergl (1969).

inundated by the freshwater Lake Bungunnia (Semple & Eldridge 1989, Bowler 1980).

Alluvial deposits were laid down in the eastern part of the Basin from the late Tertiary until recent times. The entire plain consists of interbedded sand and clay which was deposited by prior streams from the Palaeozoic eastern highlands. Butler (1958) proposes three main intervals of deposition, between which there were periods when the streams entrenched their beds and no deposition occurred. These streams were independent of the present day rivers and are still visible on the plain surface today (Schumm 1968). The present surface of the Plain is therefore a relict landform representing the final phase of prior stream deposition. The youngest prior streams are aged at around 36,000 years (Pels 1964b), indicating that their activity ceased in the late Pleistocene.

After prior-stream activity ended, the drainage pattern of the plains underwent major changes. Some of the major prior streams acted as drainage lines while present rivers cut across and in part along them. This coincided with a period of increased aridity (Hawkins & Walker 1956). The most recent fluvial deposit forms the floodplain of the Murrumbidgee River and filled the ancestral Murrumbidgee River cutting (Butler 1950). The interconnected basins of the Willandra Lakes System, west of the mapped area, were fed by the Willandra Billabong Creek, a distributary stream which left the Lachlan River near Hillston. This creek ceased to flow some 15 000 years ago and the lakes dried out. Willandra Creek, presently situated in the far north of the Hay Plain, formerly flowed into the Murray River but its flow was taken over by the Lachlan River. Under the present drier climate it terminates in a series of dry lakes, salt pans and depressions, the modern-day terminus being Gunnaramby Swamp just west of the mapped area.

Tectonic movements may have been responsible for the change from prior stream courses to present-day river courses. A striking feature of the southern Hay Plain is the deflection of the Murray River and the displacement of prior streams, by the Cadell Fault (Harris 1939). The Fault, visible as an uplifting of the floodplain between Echuca and Deniliquin, stopped the usual flow of the Murray River from Tocumwal westward to Barham. The river formed two new outlets, the present Murray River to the south through Echuca and the present Edward River to the north through Deniliquin. The uplift is only 20 m high and is straddled by the Cobb Highway north of Echuca. This relatively recent tectonic event is estimated to have occurred about 20 000 years ago (Bowler 1967).

Geomorphology

The geomorphology of the Hay Plain is essentially fluvial in character, with minor aeolian and lacustrine elements (Fig. 4). Stream deposition has given the Plain its form, with erosion to a lesser extent. It is basically an inland floodplain with some low relief, dissected by rivers, creeks and ancestral and prior streams. Butler *et al.* (1973) defined it as a series of gently sloping alluvial fans and the floodplains onto which they merge. Isolated low rises to less than 100 m elevation occur throughout the area. Aeolian forces have shaped the landscape further north and west where sandplains, dunefields and low rocky outcrops arise.

Plains

Fluvial elements have produced plains with different surface characteristics. The Hay Plain may be broadly divided into three geomorphological types based on the major floodplains: the southernmost, uplifted and heavily channelled plains of the Murray which receive the highest rainfall, the highly scalded plains of the Murrumbidgee, and the broad Lachlan River plain which receives the lowest rainfall and has many



Figure 4. Geomorphology and landform features of the mapped area, based on Butler *et al.* (1973). Spotted areas are Palaeozoic ranges, hills and associated slopes. Double-hatched areas are dunefields. Lightly-hatched areas are aeolian plains. Black areas show source-bordering dunes, lunettes and lunette remnants. Unhatched areas indicate plains: unlabelled — plains with depressions, or lakes; C — channelled plains; S — scalded plains; F — featureless plains.

low depressions (Morgan & Terrey 1992). The Plain surface consists predominantly of clays that were deposited from prior streams when water was isolated beyond the levees on extensive floodplains (Pels 1969a). Consequent fluvial forces have produced alluvial plains with depressions, channels or little feature.

Present rivers

River channels such as those of the Murrumbidgee and Lachlan are deep and narrow, with steep clay banks and carry a large proportion of their sediment load in suspension. These present rivers are not old but are new eroding channels, cutting through alluvial deposits bought down by prior streams (Butler 1950). They form a branching system which eventually feeds into the Murray River (Butler *et al.* 1973). Stream flow is variable and during dry periods many of the smaller creeks dry up completely. Even major creeks and rivers, or portions of them, have been known to dry up during prolonged drought. Most rivers or creeks on the Plain terminate in lakes, salt pans or dunefields but several of them, such as the Edward and Wakool Rivers, branch off the main stream and rejoin again, forming an anabranch. Often the stream breaks up into a complex system of smaller creeks and channels as seen in the drainage system of the Lachlan River within the mapped area.

Prior streams and ancestral rivers

Two types of ancient stream systems have been identified on the basis of their form and age (Butler 1950). Prior streams are indicated by low, winding, sandy rises on the clay floodplain; these are elevated remnants of the old stream beds. Associated with these rises of coarse alluvium may be low, fixed sand dunes, described as source-bordering and formed by the redistribution of the coarse stream bed deposits derived from the old levees. Ancestral rivers are a younger system of remnant channels with the beds of sediment below the level of the adjacent plain. These often carry water during floods.

While current and ancestral rivers carry much of their sediment in suspension, prior streams were of a bedload type, depositing their sediments (Schumm 1968). The current bed level of prior streams is higher than the adjacent floodplain due to their once-depositional nature. Prior streams near Griffith have been aged at 36 000 years (Pels 1964b) and ancestral rivers between 30 600 and 4 200 years (Pels 1969b). Pels (1964a) also found that prior streams pre-dated the Cadell Fault and ancestral streams mostly post-dated it. Prior stream remnants today carry a different vegetation from the surrounding plain and other stream types.

Lakes

The dry basins of shallow lakes are a common geomorphological feature of the Hay Plain. Permanently filled natural lakes are less common, most being artificially-filled reservoirs or evaporation basins for irrigation or drainage. The lakes are generally circular, elliptical or kidney-shaped in outline with the long axis aligned north-south. The beds of dry lakes tend to have the characteristics of the adjacent plain and a dune ridge or lunette of sandy sediment overlying clay may be present along the eastern edge.

Aeolian landforms

Aeolian elements are not common on the Hay Plain and take the form of isolated low dunes, lake lunettes formed by the accumulation of sandy material and sandplains overlying deeper clay soils and which are often scalded. Sand dunes vary in height from 3–15 m and most are source-bordering, usually associated with prior streams and to a lesser extent with ancestral rivers (Pels 1964a, Bowler & Harford 1966).



Figure 5. The distribution of soil types within the mapped area, based on Eldridge (1990). Unhatched areas indicate clays: unlabelled — deep, grey, cracking clays; Y — deep, yellow, cracking clays; A — ancestral streams and floodplain complex. Dashed areas are the red-brown earths group of hard, duplex soils (M — massive red earths in the east between Hillston and Griffith). Lightly-hatched areas are desert loams (calcareous earths). Double-hatched areas indicate deep, loose sands. Spotted areas are lithosols of shallow sandy soils.

Lunettes are generally crescent-shaped, following the curvature of the lake on its eastern edge (Butler *et al.* 1973). Scalding is the result of the removal of surface soil by wind, leaving bare areas of harder B-horizon soils which can vary from patches a few meters in diameter to vast areas of several square kilometres. Unvegetated, scalded areas are common on the Hay Plain.

Other aeolian sediments apart from the sand dunes and scalds occur on the Plain. Clay sheets, termed 'parna' by Butler (1956), occur over much of the Plain or interbedded with fluvial sediments. They consist of redistributed materials derived mainly from prior stream levees and beds and are apparently more common on the eastern edge of the Hay Plain as a sheet 1–2 m thick (Schumm 1968). The source of the parna was to the west and is evidence of a period of severe aridity separating the last two phases of prior stream activity (Butler 1950).

Soils

The predominant soils of the Hay Plain are deep, self-mulching, cracking clays (Fig. 5), consisting of grey, brown and red clays. Hard duplex soils of red-brown earths overlying grey and brown clays are seen in the north-east of the mapped area while desert loams of crusty red duplex soils are common further west and north. Isolated sandy rises and lunettes occur throughout, with deeper sandplains to low dunefields occurring at the north-west to north-east edges of the mapped area. Prior streams of coarse sand to gravel are common in the south-eastern sector of the mapped area.

Soil fertility is generally low in arid zone soils which are deficient in nitrogen and phosphorus (Leigh & Noble 1972). Soluble salts and pH increase with depth throughout the soil profile while organic matter and nitrogen levels decrease (Dalton 1988). There is a great amount of organic matter input from annual and short-lived perennial species when they die off over summer, while long-lived perennial species such as *Atriplex vesicaria* deposit organic matter into the soil year-round (Rixon 1970). Little nitrogen input is available to plants from sheep faecal pellets due to their slow and inefficient breakdown in the dry soils (Rixon 1970). Soil salinity and surface calcareousness increases across the Plain corresponding with increasing aridity (Butler *et al.* 1973).

The following soil categories are based on Eldridge (1990) while those in brackets are from Abraham (1987):

Grey, brown and red clays (Coarsely cracking clays)

As the most extensive group of soils found in the area, the clays occur on the beds and floodplains of the major river and creek systems, on low-lying areas of the plain and in lake beds. The grey clays occur on lower-lying areas while the brown and red clays are generally found on higher, better drained sites (Eldridge 1990). Gilgai development is often seen in clays occupying lower levels (Dalton 1988). Deep grey clays are most common in the north and west of the Hay Plain while deep yellow-grey clays are associated with the Willandra Lakes System, ancestral streams, the Lowbidgee floodplain and the Darling River. Clay soils are less susceptible to erosion than sandy or loamy soils due to their compact nature.

Red-brown earths (Scalded red texture-contrast soils)

These soils occur over an extensive area of the eastern and southern riverine plain, grading into areas of grey and brown clays further west. They are moderately fertile texture-contrast soils with hard setting topsoils prone to structural breakdown (Abraham 1987). They occur south-west to north-east of Deniliquin and north-east of Hay, on elevated plains and prior-stream levees. Wind erosion is prevalent on this soil

type and scalds are common, especially on the levees of prior streams. Water infiltration and holding capacities of these soils are generally high (Eldridge 1990).

Desert loams (Calcareous earths)

These soil types are usually found in the transition zone between the riverine and aeolian plains. They are characterised by a brown sandy loam to loam surface with a brittle crust, overlaying red to red-brown clay subsoils with an accumulation of calcium carbonate (Eldridge 1990). These soils are also susceptible to windsheeting and scalding.

Sands

Many isolated and semi-continuous sandhills occur throughout the mapped area. Earthy sands are found on dunes, lunettes, sandy rises and in sandy swales. Sandplains and low dunefields with deeper sands supporting mallee mark the start of the aeolian landscape in the north-west to north-east. The coarse channel sediments of prior streams comprise gravelly sand, clayey sand or light sandy clay loam. The sediments of prior stream levees grade from sandy clay loam to fine sandy clay (see red-brown earths) textures.

Palaeovegetation

The pollen floras from inland Australia are mostly of lower Tertiary age and indicate the existence of closed forests, with abundant *Nothofagus* in pollen assemblages (Martin 1981). The arid zone flora of Australia began to develop during the Miocene, approximately 15 million years ago (Barlow 1981). There is little evidence of the development of the modern *Eucalyptus* flora or of the arid flora because of the bias of pollen preservation towards permanently wet sites (Martin 1981). It appears that it was too dry for abundant pollen preservation to the west of Narrandera. In the Murray Basin during the Eocene, about 45 million years ago, Martin (1978) found that *Nothofagus* pollen types were most abundant in the fossil record, followed by Casuarinaceae, gymnosperm, Proteaceae and Myrtaceae.

Geographic variation appears to have occurred in Tertiary floras and vegetation (Martin 1981). The disappearance of *Nothofagus* and its associated flora during the Mid-Miocene about 15 million years ago coincides with developing aridity. A gradient in the Pliocene pollen assemblages (about 5 million years before present) appears to parallel the east-west climatic gradient in western New South Wales. The change to open woodlands and forests and savannah coincides with the onset of a marked seasonal dry period.

Vegetation

Descriptions of the Hay Plain are almost synonymous with the adage 'saltbush plains'. *Atriplex vesicaria* and *Maireana aphylla*, with *Atriplex nummularia* to a far lesser extent, are the principal species of these shrublands that dominate the landscape. Perennial saltbush shrublands extend discontinuously from the riverine plain in New South Wales to large areas of South Australia and to southern Western Australia (Dalton 1988). A network of current and ancestral rivers and creeks supports *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* woodlands while scattered low sandy rises and prior streams carry *Callitris*-dominated remnants. The perennial grasslands in the east of the Plain are indicative of greater land use in this higher rainfall area. The change from alluvial to aeolian landscapes in the north-west is marked by sandplains carrying *Casuarina pauper* and *Alectryon oleifolius* open woodlands, *Maireana pyramidata* and *Maireana sedifolia* shrublands, and mallee communities.

The vegetation of the Hay Plain was mapped by Beadle (1948) as an essentially homogeneous area of *Atriplex vesicaria*. While *Atriplex vesicaria* shrubland dominates the Plain today, much of it has been modified by intensive grazing and dieback events. The most widespread change in recent years to the low shrublands has been the replacement of *Atriplex vesicaria* by *Maireana aphylla*. The composition of these and other chenopod shrublands has been further modified with the establishment of *Sclerolaena* species, annual *Atriplex*, *Nitraria billardierei* and other species indicative of disturbance.

Aboriginal History

The Aboriginal people have occupied the country for at least 30 000 years, with the earliest known evidence coming from Lake Mungo east of the Hay Plain (Flood 1990). Several large Aboriginal tribes lived around the rivers and on the Hay Plain itself. The Wiradjeri tribes lived on the plains east of the Darling (Mullins *et al.* 1982). The Nari-Nari, Mudi-Mudi and Gurendji occupied areas of the Murrumbidgee River between Hay and the Great Cumbung Swamp while the Yida-Yida lived near the Lachlan River north-west of Hay. Tribes along the Murray River from east to west included the Banggarang, Yota-Yota, Baraba-Baraba, Wamba-Wamba, Wadi-Wadi and Dadi-Dadi (NSW Department of Lands 1987). Charles Sturt's encounters with the Aboriginal people along the Murrumbidgee River were published in 1833, in the accounts of his expeditions.

Many plant species were used by the Aboriginal people of the area. They yielded edible tubers, fruits and seeds, wood, fibre and other materials. The ripe orange fruits of *Pittosporum phylliraeoides* were eaten and the sticky red seeds pounded into a flour. The berries of the Emu Bush (*Eremophila longifolia*), and the ripe fruits and oily seeds of the Quandong (*Santalum acuminatum*), were also eaten. The starch-rich spore capsules of *Marsilea drummondii* were a valuable food source for Aborigines, although they preferred other foods and used it more as a standby during dry periods (Mullins *et al.* 1982). The starchy pith of *Typha* species (bulrushes) was eaten as cakes and the fibre used for nets and bags. Grass seeds were gathered by the women and used for flour (Beveridge 1883).

The Aboriginal people also depended on the rivers, which would be full after winter rains, yielding fish, yabbies (freshwater crayfish), mussels, tortoises and water-fowl. Fish was the principal component of the diet for eight months in the year (Beveridge 1883). Away from the rivers, out on the plains, survival depended on water-finding skills. Soaks and wells were dug to tap underground seepage, water from rare rain showers was collected, and often the roots of *Hakea* and mallee species were tapped for their stored water. Active changes were made to the environment, with the burning of shrublands to flush out small animals and other game. Rock fishtrap complexes were also built and creeks were dammed. Temporary dwellings called mia mias were built on the open plains from mulga wood interlaced with sods of grass, although this was probably more common further west (Mullins *et al.* 1982, Beveridge 1883).

A number of Aboriginal sites have been recorded for the Hay Plain, including campsites, middens and ceremonial sites. An Aboriginal art site exists in the Booligal area and canoe trees are occasionally seen in the riverine forests. Small amounts of land are held by Aboriginal Land Councils and other bodies at sites in the area, including freehold land at Balranald and a leasehold site at Moonacullah just north of Deniliquin (New South Wales Department of Lands 1987).

European exploration and settlement

The first attempted traverse of the Hay Plain was by John Oxley in 1817. His party crossed the Cocoparra Ranges, travelled to Rankin Springs and down the Lachlan River until they were stopped by the much-branching *Muehlenbeckia florulenta* swamps downstream of Booligal. In 1836 Thomas Mitchell succeeded in following the Lachlan to its junction with the Murrumbidgee River. Charles Sturt explored the Murrumbidgee and Lower Murray Rivers during two expeditions between 1828 and 1831 (Sturt 1833). He made many references to the Hay Plain noting that '*... nothing could exceed the apparent barrenness of these plains, or the cheerlessness of the landscape.*' On the vegetation he remarked '*... we journeyed mostly over extensive and barren plains ... covered with the salsolaceous class of plants, so common in the interior ... and were as even as a bowling green ... We passed a very large plain in the course of the day, which was bounded by forests of box, cypress, and the acacia pendula, of red sandy soil and parched appearance.*' (Sturt 1833).

Between 1835 and 1839, pastoral runs averaging 20 000 to 40 000 ha were taken up as far west as Hay (Semple 1990). They were mainly stocked with cattle and were situated along the Murray and Murrumbidgee Rivers and the Yanko and Billabong Creeks. By 1845 land had been taken up as far west as the Murray–Murrumbidgee junction with stations averaging 80 000 ha. Some of the older stations still existing today include 'Uardry' (1840), 'Deniliquin' (1842), 'Eli Elwah' (1844) and 'Nap Nap' (1845). With the discovery of gold in Victoria in the 1850s, the Hay Plain became a fattening ground for travelling stock heading for the goldfields and this coincided with the development of stock routes linking the major towns on the Plain (Dalton 1988). Sheep grazing became the dominant pastoral activity during the 1860s, with riverboats emerging as a major form of transport. Hundreds of pastoral properties and holdings now exist on the Hay Plain, with the townships of Hay and Deniliquin as major centres.

Land Use

Sheep grazing for wool production is the main land use in dryland areas such as the Hay Plain (Semple 1990). In 1893–1895 stocking rates were about 2.5 sheep per hectare in the Deniliquin area, about the same as present stocking rates on irrigated, improved pasture. By the turn of the century, the extent of land degradation in the Western Division due to the combined effects of overstocking, droughts and rabbits was severe. This led to the appointment of a Royal Commission, which resulted in the passing of the Western Lands Act of 1901, previously administered by the Western Lands Commission (Grant 1989) and now administered by the New South Wales Department of Conservation and Land Management, Western Division. A more current sheep stocking rate on the saltbush plains is 0.4–0.8 sheep per hectare (Leigh & Noble 1972). The grasslands and saltbush plains are considered the most productive of the semi-arid grazing lands of southern Australia and the mallee lands the least productive (Semple & Eldridge 1989), although mallee communities are considered to have a high biological diversity (Calder 1990).

Cropping commenced on a small scale in the 1880s, south of Deniliquin. Most of this was dryland cropping with some irrigation at Mildura. The areas south of Hillston and Balranald were first cleared for cropping in the early 1900s. The general area of crops increased considerably after the First World War but dropped off during the Depression of the late 1920s to early 1930s. Large, state-sponsored irrigation schemes were implemented before and immediately following the Second World War. The state-sponsored Murrumbidgee Irrigation Area has been described as the richest tract of agricultural country in Australia. Other irrigation programs on the riverine plain

include the Hay, Colleambally and Tullakool Irrigation Areas. Many smaller holdings are part of private irrigation schemes. The main rural products are wool, beef, mutton, horticultural products, wine, rice, winter cereals and River Red Gum timber with increasing wheat production in dryland areas (Semple 1990). Clearing and cultivation on Western Division leasehold land are controlled by the Department of Conservation and Land Management, Western Division.

Prior streams are exploited as a source of sand and gravel for road building and numerous small pits and quarries have been opened in the major stream beds across the Plain. In recent years, existing sandhills on the Hay Plain have been developed for potato growing, although wind erosion is a big problem in these areas (Semple & Eldridge 1989). Soil loss due to land use has been high in certain pastoral situations and it is believed that much of the damage was done in the first 20 to 40 years of European settlement (Denney 1992). Rabbits were introduced into the area in the 1870s and rapidly multiplied, with almost a million killed on 'Tupra' station in 1890 (Semple 1990). They have been the cause of widespread land degradation on the Hay Plain and elsewhere in western New South Wales.

Previous botanical surveys

General surveys for western New South Wales

As research officer and botanist for the Soil Conservation Service at Condobolin, Noel Beadle comprehensively mapped the vegetation of western New South Wales in the late 1940s. He identified 35 plant associations and 'associates' for western New South Wales and produced a vegetation map at approximately 1:1 000 000 scale (Beadle 1948).

Stannard (1958 & 1963) conducted erosion surveys for the south-west Cobar peneplain and the central east-Darling region and included vegetation and soil maps for each of these areas. The vegetation classification was based on the work of Beadle (1948). Parts of these maps coincide with the far north-east and far north-west corners of the current survey area respectively.

The Anabranck-Mildura (Fox 1991) and Balranald-Swan Hill (Scott 1992) 1:250 000 vegetation maps have been published as part of the western component of a vegetation mapping program at the Royal Botanic Gardens in Sydney. A 1:1 000 000 vegetation map of north-western New South Wales has also been prepared (Pickard & Norris, *in press*).

Technical manuals, graziers' guides and literature surveys covering a wide range of vegetation types and species have been compiled by the New South Wales Soil Conservation Service (now incorporated in the Department of Conservation and Land Management); these cover the Hay Plain and western New South Wales generally.

Land Systems Maps (Walker 1991) have been published for the whole of the Western Division, including the Booligal-Hay 1:250 000 area. These maps describe the recurring patterns of vegetation, soils and topography. Various species lists have been compiled for Soil Conservation Service experimental exclosures established between 1950 and 1952 and for other study sites across the Plain, by Cunningham and Milthorpe (1981) and Semple (1986).

Surveys covering the Hay Plain

Leigh and Mulham (1977) and Mulham and Jones (1981) compiled a comprehensive species list for the riverine plain with notes on distribution and pastoral use. Moore (1953) conducted an ecological survey and produced a vegetation map of the south-

eastern Riverina directly east of the present survey area. He discussed the concepts of climax and disclimax vegetation associations, identifying 23 communities (Moore 1953).

The riparian vegetation of the Murray River was mapped at 1:50 000 scale from Albury to Lake Alexandrina in South Australia (Margules & Partners *et al.* 1990). A total of 37 riparian communities were identified. Pressey *et al.* (1984) mapped the vegetation of the Lachlan–Murrumbidgee confluence situated in the west of the Hay Plain.

A survey of *Atriplex vesicaria* extent was conducted in 1987 by the Hay Soil Conservation Service, after widespread occurrences of dieback on the Hay Plain (Clift *et al.* 1987, Clift *et al.* 1989 and Semple 1989). The riverine plain was mapped for remnant Bladder Saltbush using data provided by local landholders (Soil Conservation Service of New South Wales unpubl.)

Sites are currently monitored throughout the Plain as part of the Rangeland Assessment Program by the New South Wales Department of Conservation and Land Management. Species have also been recorded for Willandra National Park by the New South Wales National Parks and Wildlife Service (1985–1988).

Methods

Mapping

The composition and extent of the present native vegetation, both remnant and modified was mapped for the Booligal–Hay and Deniliquin–Bendigo 1:250 000 map sheets (see back pocket). Black and white aerial photomosaics and photographs produced by the New South Wales Department of Lands (now the Land Information Centre of the Department of Conservation and Land Management) were used to define plant community boundaries. The photo-interpretation was checked and confirmed or modified by extensive site sampling and field traverses. Provisional vegetation maps were drafted at 1:100 000 scale and reduced to the published scale of 1:250 000. These and other sources of information used for compiling the maps are indicated in Table 2.

Some problems were encountered in interpreting the aerial photography of the Plain. Boundaries between some vegetation types, particularly shrublands and grasslands, are gradational. Mallee, riparian and other tree communities are more readily delineated on aerial photographs. Much ground truthing was thus required to define the extent of grassland and shrubland. Vegetation boundaries were often indirectly determined from the more distinct geomorphological features on the aerial images. While older photomosaics formed the basis for the mapping, contemporary vegetation was updated from recent stereo photography and LANDSAT imagery. Small remnants (smaller than 100 ha) were not mapped because of the scale employed for publication.

Survey

The vegetation survey was conducted over three years, with nine field trips totalling 15 weeks between February 1990 and October 1992. Of these, five were undertaken during the spring, three in autumn and one trip at the end of summer. The Booligal map area was surveyed in May 1992 during drought conditions and in October 1992 after limited winter rainfall. Fig. 6 indicates site locations and major field traverses across the mapped area.

Table 2. Information sources and data used in compiling the Booligal-Hay and Deniliquin-Bendigo 1:250 000 vegetation maps.

Source	Year	Data	Scale
Beadle, N.C.W.	1948	western NSW vegetation survey	1:1 013 760
New South Wales Department of Lands	1960-69	aerial photomosaics	1:50 000
Division of National Mapping (NATMAP)	1975-88	topographic maps	1:50 000 1:100 000 1:250 000
Pressey, R.L. <i>et al.</i>	1984	Cumbung Swamp vegetation survey	1:50 000
New South Wales Department of Lands	1986-90	stereo-paired aerial photos	1:49 000- 1:86 000
Soil Conservation Service of New South Wales (unpubl.)	1987	original maps and questionnaires from <i>Atriplex vesicaria</i> survey	1:250 000
Margules and Partners <i>et al.</i>	1990	Murray River riparian vegetation survey	1:50 000
Walker, P.J. (Department of Conservation and Land Management)	1991	Land Systems maps	1:250 000
Australian Centre for Remote Sensing	Dec. 1992	LANDSAT TM satellite imagery	1:250 000

The selection of sites was based on recognised photopatterns, accessibility and the condition of the vegetation on the ground. Additional areas of relatively undisturbed vegetation were sampled or checked on the advice of local experts. A total of 94 sites with a minimum area of 0.1 ha were fully sampled for vegetation, soil, disturbance and other environmental variables while species lists and descriptive information were collected for a further 153 sites. For the Hay and Deniliquin map areas, all species present were recorded within a sampling area of 0.2 ha (100 X 20 m). This was reduced to 0.1 ha (50 X 20 m) for the Booligal area after analysis of species area curves. Data were also collected on plant density, percentage cover, height of strata and relative strata cover. Percentage cover within the first 100 m² of the quadrat was assessed. Additional information on structure, landform, soils, disturbance and regeneration was recorded for each site. Soil samples and salinity data (using an EM-38 salinity meter) were collected for a subset of sites. Species lists were also made for numerous spot sites across the Plain.

Structural and floristic classification of the vegetation

The site data collected were used to describe the vegetation communities floristically and structurally. The structural classifications of Specht (1981) and Walker and Hopkins (1990) were employed. Community floristic composition was based on perennial vegetation and the vegetation units named after the dominant species of the tallest stratum. Where this was inappropriate, geological references were used in the naming of the community. Associated species are listed for each vegetation unit in order of abundance. Ground-cover species are listed separately where appropriate.

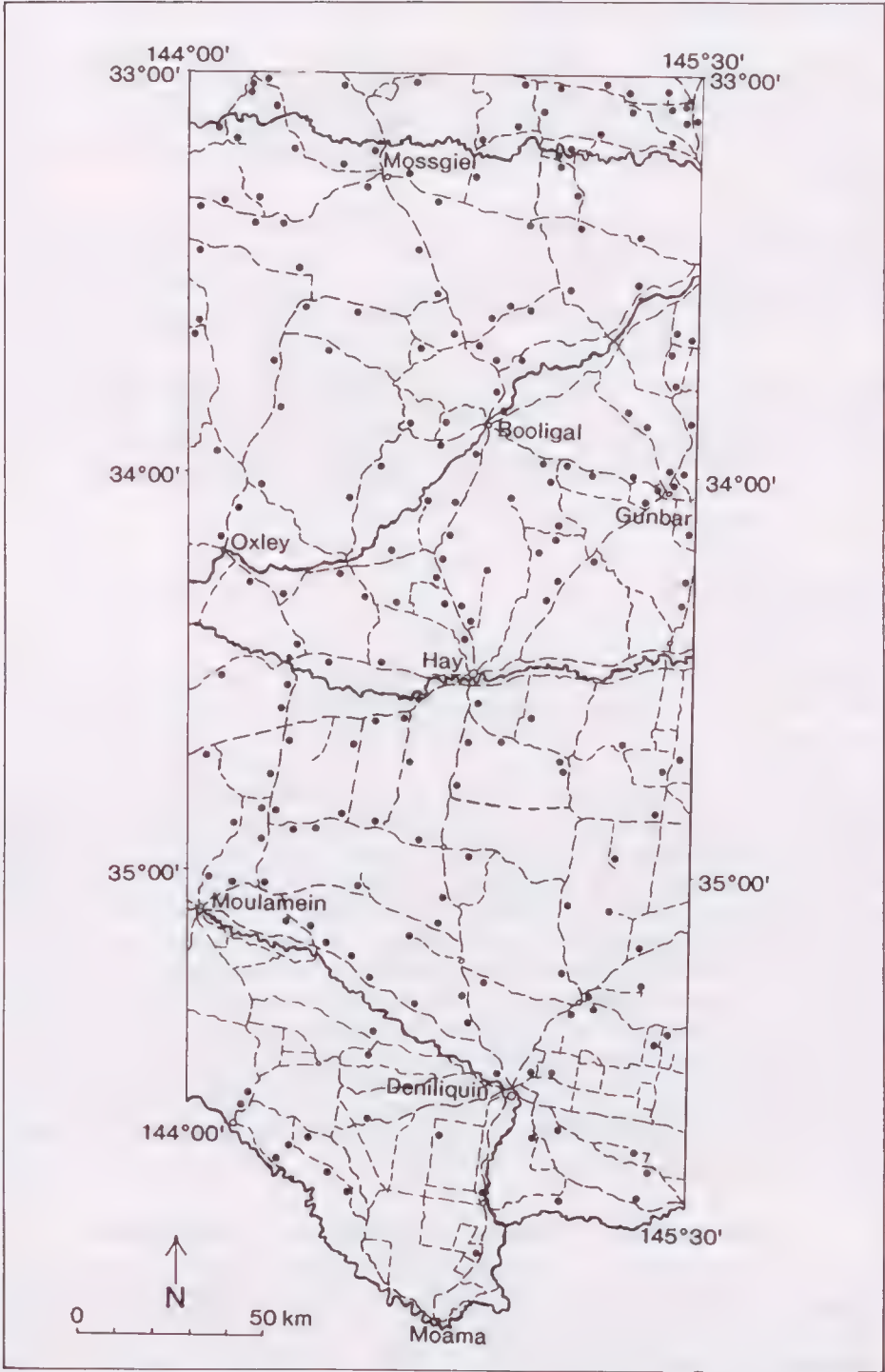


Figure 6. Site locations (dots) and major field traverses (dashed lines) across the mapped area (from fieldwork undertaken between February 1990 and November 1992).

The concepts of vegetation community and plant association have been variously defined. Beadle classified the vegetation of western New South Wales into major associations, each containing a number of types. The term 'type' is used to describe botanically uniform communities while an 'association' is defined as an aggregation of botanically related types (Beadle 1948). Beadle (1948) mapped the vegetation of western New South Wales at the 'association' level. In this survey, floristically uniform plant groupings are described and mapped as vegetation communities. This is equivalent to Beadle's 'type' ranking, and with the term 'association' as used by later authors (Beadle & Costin 1952, Moore 1953, Beadle 1981). The 'association' unit was redefined as a climax community in which the dominant stratum has a uniform floristic composition and structure (Beadle & Costin 1952). It should be noted that the term 'association' as used by Beadle (1948) was a more encompassing term, and is equivalent to the 'alliance' unit used in later publications to group floristically related associations (Beadle & Costin 1952, Moore 1953).

The botanical names used throughout the present survey are those currently recognised by the National Herbarium of New South Wales, and follow Harden (1990–92).

Community descriptions

Twenty-one vegetation communities are identified on the Booligal–Hay and Deniliquin–Bendigo 1:250 000 map sheets, represented by map units 1 to 29 (Table 3). Two cleared units are also recognised. Structural types range from grassland to open forest, including woodland, mallee shrubland and chenopod shrubland. Community structure is based on Specht (1981) # and Walker and Hopkins (1990) ##. An asterisk * indicates an exotic species. (B), (H), or (D) after a species indicates whether or not it is restricted to a particular map area: Booligal, Hay and Deniliquin–Bendigo respectively.

The vegetation communities

Map unit 1: Riverine Forest

Structure: open forest # and ##

Main species: *Eucalyptus camaldulensis* (River Red Gum)

Associated species: *Acacia stenophylla*, *Muehlenbeckia florulenta*, *Eucalyptus largiflorens*, *Chenopodium nitrariaceum*, *Acacia salicina*, *Eucalyptus microcarpa* (D), *Juncus ingens* (D), *Exocarpos strictus* (D), **Lycium ferocissimum*.

Ground-cover species: *Pratia concolor*, *Glinus lotoides*, *Oxalis perennans*, *Centipeda cunninghamii*, *Paspalidium jubiflorum*, *Alternanthera denticulata*, *Chamaesyce drummondii*, *Cotula australis*, *Marsilea drummondii*, *Carex appressa*, *Poa fordeana*, *Agrostis avenacea*, **Cotula bipinnata*, **Stellaria media* (D), **Solanum nigrum*, **Sonchus oleraceus*.

Landform: River and creek levees and adjacent flats, channelled plains and other areas subject to frequent or periodic flooding.

Soils: Heavy grey, brown and red clays.

Occurrence: This community occurs along the major river systems of the Murray, Edward–Wakool, Murrumbidgee and Lachlan Rivers and other rivers and creeks throughout the mapped area: (Figs 7 & 8). In the drier north, creeks and rivers tend to be fringed with *Eucalyptus largiflorens* (Black Box), although *Eucalyptus camaldulensis* will occur with Black Box wherever periodic flooding occurs. Dense stands of

Table 3. Plant communities of the Booligal (B), Hay (H) and Deniliquin-Bendigo (D) 1:250 000 map sheets with map unit and main species. Structure is based on Specht (1981) # and Walker & Hopkins (1990) ##. Equivalent map units used by Scott (1992) for the adjacent Balranald-Swan Hill map sheet are also indicated (Bal. No.).

No.	Plant Community	Main Species	Structure	Map	Bal. No.
1	Riverine Forest	<i>Eucalyptus camaldulensis</i>	open forest # & ##	BHD	1
2	Black Box Woodland	<i>Eucalyptus largiflorens</i>	woodland #; woodland - open woodland ##	BHD	2
3b	Dune-Crest Mallee	<i>Eucalyptus socialis</i> , <i>Eucalyptus dumosa</i> , <i>Triodia scariosa</i>	tall shrubland #; mallee shrubland - open mallee shrubland ##	B	3b
3d	Sandplain Mallee	<i>Eucalyptus socialis</i> , <i>Eucalyptus dumosa</i>	tall shrubland #; mallee shrubland - open mallee shrubland ##	B	3d
4	Belah-Rosewood	<i>Casuarina pauper</i> , <i>Alectryon oleifolius</i> subsp. <i>canescens</i>	low - low open woodland #; open woodland - isolated clumps ##	B	4
8	Black Bluebush	<i>Maireana pyramidata</i>	low - low open shrubland #; chenopod shrubland - sparse chenopod shrubland ##	BH	8
8p	Black Bluebush and Pearl Bluebush	<i>Maireana pyramidata</i> , <i>Maireana sedifolia</i>	low - low open shrubland #; chenopod shrubland - sparse chenopod shrubland ##	BH	9
11	Bladder Saltbush	<i>Atriplex vesicaria</i>	low - low open shrubland #; chenopod shrubland - open chenopod shrubland ##	BHD	11
12	<i>Sclerostegia tenuis</i>	<i>Sclerostegia tenuis</i> , <i>Disphyma crassifolium</i> subsp. <i>clavellatum</i>	low shrubland #; closed - open chenopod shrubland ##	BHD	-
13	Canegrass	<i>Eragrostis australasica</i>	tussock grassland # & ##	BHD	13
16	<i>Callitris</i> Mixed Woodland	<i>Callitris glaucophylla</i>	woodland - low open woodland #; woodland - isolated clumps ##	BHD	16
17	<i>Acacia melvillei</i> Woodland	<i>Acacia melvillei</i>	tall shrubland - low woodland #; shrubland - woodland ##	BHD	17

18	Lignum and <i>Chenopodium nitriaceum</i>	<i>Muehlenbeckia florulenta</i> , <i>Chenopodium nitriaceum</i>	low shrubland - open scrub #; open - closed shrubland ##	BHD	18
19	Old Man Saltbush	<i>Atriplex nummularia</i>	low - open shrubland #; chenopod shrubland - open chenopod shrubland ##	BHD	19
21	Cotton Bush	<i>Maireana aphylla</i>	low - low open shrubland #; chenopod shrubland - sparse chenopod shrubland ##	BHD	21
22	Dillon Bush	<i>Nitratia billardierei</i>	low - low open shrubland #; shrubland - sparse shrubland ##	BHD	22
23	Great Cumbung Swamp	<i>Phragmites australis</i> , <i>Senecio cunninghamii</i> , <i>Typha orientalis</i> , <i>Typha domingensis</i>	closed - open herbland/ grassland #; closed - open grassland/rushland/forbland ##	H	23
24	Grey Box Woodland	<i>Eucalyptus microcarpa</i> , <i>Allocasuarina luehmannii</i>	low woodland - woodland #; open woodland - woodland ## (occasionally to open forest # and ##)	D	-
25	<i>Acacia pendula</i> Woodland	<i>Acacia pendula</i>	low - low open woodland #; open woodland - woodland ##	BHD	-
26	White-top Grassland	<i>Danthonia caespitosa</i>	tussock grassland - open tussock grassland #; grassland - open grassland ##	BHD	-
27	Prior Stream Remnant Woodland	<i>Callitris glaucophylla</i> , <i>Hakea leucopetala</i> , <i>Hakea tephrosperma</i>	low open woodland #; open woodland - isolated trees ##	BHD	-
28	<i>Casuarina pauperl</i> / <i>Casuarina cristata</i> Intergrading Population	<i>Casuarina pauperl</i> / <i>Casuarina cristata</i> intergrades	low woodland - woodland #; open woodland - woodland ##	BH	-
29	Rocky Outcrop Woodland Complex	<i>Callitris glaucophylla</i> , <i>Eucalyptus intertexta</i> , <i>Eucalyptus vicina</i>	low woodland #; woodland to open woodland and open mallee woodland - shrubland ##	B	-
OA	Open Areas	various grasses, herb sand forbs	open herbfield #; grassland to forbland ##	BHD	OA



Figure 7. Flooded *Eucalyptus camaldulensis* open forest at Gum Creek, Boyds Bridge, south-east of Hay, in early spring (community 1).

Eucalyptus camaldulensis occur along the Murray and on its adjacent floodplain, particularly in the Barmah and Millewa State Forests, which are internationally recognised wetland habitats (Finlayson & Moser 1991). A more open *Eucalyptus camaldulensis* woodland is found on the channelled floodplain of the Lachlan River south-west of Booligal.

Condition: Old trees thinned with selective logging, resulting in a younger age class over much of the distribution of this community; forests subject to manipulated flooding regimes with regeneration greatly affected; limited weed infestation; many areas cleared for crop growing, especially in the Murray River area.

Notes: *Eucalyptus camaldulensis* requires periodic flooding for seedling germination and growth (Somerville 1988) while *Eucalyptus largiflorens* tolerates less frequent flooding and occurs on slightly higher ground on the floodplain, distant from the channel. Areas of *Eucalyptus largiflorens* that dominate these terrace landform elements have been mapped as a separate community (2). Rare hybrids of *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* occur between Barham and Swan Hill.

Eucalyptus microcarpa (Grey Box) forms extensive stands within *Eucalyptus camaldulensis* forests in the Deniliquin area. In Werai State Forest north-west of Deniliquin, *Eucalyptus microcarpa* reaches open forest proportions. Within the Murray floodplain, higher areas of red-brown earths or sands occur, carrying much-cleared woodlands of *Callitris gracilis* subsp. *murrayensis* (Murray Cypress Pine) or *Callitris glaucophylla* (White Cypress Pine) (See Community 16). These sandhills scattered throughout the River Red Gum forest are commonly about twelve metres high and are older than the floodplain itself, having been there before the Cadell Tilt uplifting (Allen 1979). A small population of *Eucalyptus leucoxylon* subsp. *pruinosa* (unmapped) exists just north of Barham, adjacent to *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* woodland and growing on grey-brown alluvial soil.

Eucalyptus camaldulensis may reach heights of up to 40 m and forms the only forest structural type in the area. A shrub layer is normally absent, with leaf and branch litter dominating the ground layer. Shrubs, if present, may include *Muehlenbeckia florulenta* (Lignum), *Chenopodium nitrariaceum* and **Lycium ferocissimum*. *Muehlenbeckia florulenta* and *Eragrostis australasica* may occur in intermittently flooded channels within the floodplain while areas of semi-permanent still water support rushlands of *Typha* spp. (Fig. 22), *Phragmites australis*, *Juncus* spp. and *Eleocharis* spp. The herbaceous layer varies seasonally and, as well as the species listed, may include *Rumex*, **Medicago*, *Echium* and **Xanthium* spp. together with exotic grasses such as **Hordeum leporinum* and **Lolium perenne*. River Red Gum forests are a good example of a unispecific community. Because of the regular flooding in their habitat, all other species are drowned and only *Eucalyptus camaldulensis* can survive (Allen 1979).

Much of the River Red Gum forest on the Murray River floodplain and areas along the Murrumbidgee River are under State Forest management and have been logged and grazed to various extents. Regeneration of *Eucalyptus camaldulensis* is poor in areas where grazing is a predominant land use. Changes in flooding regimes due to river regulation have led to a decline in the quality of stands (Margules & Partners *et al.* 1990). Natural regeneration is largely dependent on flooding (Somerville 1988) and river regulation is preventing this, for example, some stands have died along the Murray River (Allen 1979). Dense areas of *Eucalyptus camaldulensis* occur along the Murray River in the Barmah, Millewa, Perricoota and Koondrook State Forests and should be targeted for conservation. These forests are also an important archaeological resource, as they include canoe trees, camp sites, middens and burial grounds. A small area of River Red Gum is conserved within Goonawarra Nature Reserve on the Lachlan River south-west of Booligal but, with the exception of Kemendoc Nature

Reserve west of the mapped area, the community remains virtually unconserved along the Murray River in New South Wales. Some small Crown Reserves conserve River Red Gum forest areas, however these are usually discontinuous and generally not actively managed.

Map unit 2: Black Box Woodland

Structure: woodland #; woodland – open woodland ##

Main species: *Eucalyptus largiflorens* (Black Box)

Associated species: *Chenopodium nitrariaceum*, *Rhagodia spinescens*, *Atriplex nummularia*, *Enchyklaena tomentosa*, *Einadia nutans*, *Muehlenbeckia florulenta*.

Ground-cover species: *Chamaesyce drummondii*, *Atriplex semibaccata*, *Atriplex leptocarpa*, *Oxalis perennans*, *Boerhavia coccinea*, *Centipeda cunninghamii*, *Alternanthera denticulata*, **Verbena officinalis*, *Calotis scapigera*.

Landform: Uppermost floodplain levels, periodically flooded alluvial plains, ephemeral creeks and adjacent flats, dry-lake margins, depressions, drains and channels.

Soils: Heavy grey and brown clays, self-mulching or compact. Black Box woodland also occurs on the sandier soils of ancient rivers and former depressions (Semple 1990).

Occurrence: Black Box forms extensive woodlands on the terrace landform elements adjacent to major creeks and rivers across the mapped area (Fig. 9). It is also common in depressions, along major and minor creeks (especially north of the Murrumbidgee River) and fringing dry lakes. South of Moulamein and Conargo on the Deniliquin map, *Eucalyptus largiflorens* often occurs mixed with *Eucalyptus microcarpa* (Grey Box) and less commonly *Eucalyptus melliodora* (Yellow Box), gradually being replaced by the former further south on the floodplain.

Condition: Some tree dieback is apparent especially in irrigated areas; weed infestation common. Understorey generally intact and sparsely grazed, except where cleared in the southern irrigation areas.

Notes: *Eucalyptus largiflorens* is one of the most widespread and common trees in inland New South Wales, also extending into South Australia, Victoria and extreme southern Queensland. It grows on the less frequently flooded areas of the floodplain above the level of the adjacent River Red Gum forest. It also occurs in ribbon stands along intermittent creeks, fringing lakes, or as a line of very scattered individual trees along drainage lines. *Eucalyptus largiflorens* often occurs in depressions and other areas of restricted drainage within other vegetation communities such as *Callitris glaucophylla*, *Acacia pendula* and mallee woodlands.

The relatively open nature of this community has allowed for the development of an understorey of variable density and composition. The main understorey species in Black Box woodlands are *Chenopodium nitrariaceum*, *Rhagodia spinescens* and *Enchyklaena tomentosa*. *Chenopodium nitrariaceum* often extends out beyond the Black Box floodplain to form extensive shrublands, although much has been cleared for irrigated cropping. *Atriplex nummularia* occasionally forms a tall understorey to *Eucalyptus largiflorens*. Where the community occurs in wetter, periodically flooded areas, *Muehlenbeckia florulenta* may be the major understorey component.

Dieback of *Eucalyptus largiflorens* is a problem in heavily irrigated areas, particularly adjacent to the Murray River. In their survey of riparian vegetation, Margules and Partners *et al.* (1990) reported that trees were generally in poor condition over most



Figure 8. *Eucalyptus camaldulensis* forest with *Juncus ingens* understorey and ground cover of *Scleranthus minisculus* and *Stellaria media*; Edward River, Mathoura, in late winter (community 1).



Figure 9. Open *Eucalyptus largiflorens* woodland with grassy understorey of *Hordeum leporinum* and *Lolium perenne* on 'Bertangles', east of Hay, in early spring (community 2).

of their distribution along the whole of the Murray River, with Black Box in the far western reaches the worst affected. Soil salinisation from rising local water tables and salty groundwater inflows is considered a major problem along the river. Local cases of dieback around Deniliquin in the Edward–Wakool river system have also been reported (M. Driver, Greening Australia, pers. comm.). Salinity may be a contributing factor, although the causes of these and other dieback events in dryland areas are currently under investigation.

Logging has been a common practice in Black Box communities and the timber used for fencing. The area around Hay has been particularly affected, although small clumps have been retained in paddocks for stock shelter (Semple 1990). Sheep grazing appears to have limited regeneration of Black Box along the Murray River, while previous logging has led to a decline in mature trees of the species (Margules & Partners *et al.* 1990, Treloar 1959). A section of Willandra Creek supporting a Black Box woodland with a dense *Acacia stenophylla*, *Chenopodium nitrariaceum* and *Muehlenbeckia florulenta* understorey is conserved within Willandra National Park on the Booligal map area. A small area of *Eucalyptus largiflorens* associated with the Lachlan River is also conserved within Goonawarra Nature Reserve south-west of Booligal. The community is considered poorly conserved in New South Wales (Murray–Darling Basin Ministerial Council 1987).

Map unit 3: Mallee

Structure: tall shrubland to low woodland #; mallee shrubland to open mallee shrubland (rarely open mallee woodland) ##

‘Whipstick’ mallee is a low, stunted multi-stemmed growth form, indicating a sandy soil of low fertility and commonly occurring on the dune crests. ‘Bull’ mallee, a taller form with fewer stems, indicates a more fertile and less sandy soil and occurs in the heavier soils of the swales (Beadle 1948, Noble *et al.* 1980).

Main species: *Eucalyptus socialis* (Pointed Mallee) (B), *Eucalyptus dumosa* (Congo Mallee) (B).

Associated species: *Eucalyptus gracilis* (B), *Eucalyptus leptophylla* (B), *Senna artemisioides* subsp. *filifolia*, *Senna artemisioides* subsp. *petiolaris*, *Dodonaea viscosa* subsp. *angustissima*, *Acacia colletioides* (B), *Eucalyptus intertexta* (B), *Eucalyptus populnea* subsp. *bimibil* (B).

Callitris glaucophylla and *Acacia melvillei* as well as *Casuarina pauper* with *Alectryon oleifolius* form local communities within the mallee.

The following species are associated with particular geomorphological variation within the mallee:

3b Dune-Crest Mallee: *Triodia scariosa* (B), *Lomandra effusa* (B), *Olearia pimeleoides* (B), *Eremophila glabra* (B), *Eremophila sturtii* (B), *Acacia wilhelmiana* (B).

3d Sandplain Mallee: *Maireana pyramidata*, *Enchylaena tomentosa*, *Dissocarpus paradoxus*, *Rhagodia spinescens*.

Note: These shrubs occur more commonly in the Sandplain Mallee in the west of the mapped area. The Sandplain Mallee of the north-east supports a different shrub layer of mostly *Senna*, *Dodonaea* and *Acacia* species, with a high bark litter ground component.

Landform: Level to undulating sandplains and irregular dunefields with low, discontinuous, linear dunes.



Figure 10. Mallee shrubland with *Eucalyptus socialis* and *Triodia scariosa*, on dune-crest south of Roto in mid-spring (community 3b).

Soils: Calcareous red earths with sandy loam to clay loam surface and red desert loams derived from aeolian materials (Scriven 1988a, Eldridge 1990).

Occurrence: Two disjunct areas of mallee occur on the Booligal map area. In the north-eastern sector, the mallee is characterised by sandplains and low irregular dunes with some Dune-Crest mallee (Fig.10) and interspersed with higher sandhills supporting *Callitris glaucophylla* and undulating areas of Belah–Rosewood. South of Hillston the mallee is of the ‘bull’-type, with large, few-stemmed trees (Fig. 11). Due to extensive cropping in this area the mallee is very much of a remnant nature with a cleared understorey. North of Hillston and extending north and north-west to Roto and Trida railway sidings, extensive stands of whipstick mallee occur with a well-developed shrubby understorey. The second area of mallee occurs in the aeolian-alluvial geomorphological transition zone in the west. Aeolian sandplains carrying mallee with a *Maireana pyramidata* (Black Bluebush) understorey occur on the south-western edge of the Booligal map. This is primarily within Belah–Rosewood country (see Community 4) along the Clare-Oxley and Hatfield roads. Extensive dunefields supporting mallee on the dune crests and Belah–Rosewood in the swales occur further west.

Condition: Many areas (especially south of Hillston) severely cleared or thinned; dunes largely cleared; some soil erosion due to rabbit infestation and some scalding in open areas; areas of woody shrubs present; some areas subject to wildfire; few old stands remain, mostly of the ‘whipstick’ form. Dense mallee areas with intact understoreys exist along the railway lines in the north-east.

Notes: In New South Wales, mallee mainly occurs in the far south-west largely intact, and in a central area, much of which has been cleared for cereal growing and is now roughly bounded by Ivanhoe, Cobar and Condobolin (Scriven 1988a). *Eucalyptus socialis* and *Eucalyptus dumosa* are amongst the main species present in these mallee lands, with structural variations in different habitats (Lawrie & Stanley 1980). In the east of the mapped area, stands of *Callitris glaucophylla* and Belah–Rosewood occur intermixed with the mallee. *Eucalyptus intertexta* (Western Red Box), and *Eucalyptus populnea* subsp. *bimbil* (Bimble Box), also occur occasionally. A different mallee community exists in the west of the mapped area in the transition zone from alluvial to aeolian landforms. Here on the sandplain the mallee has a low, open, shrubby understorey of *Maireana pyramidata*, *Rhagodia spinescens* and *Enchylaena tomentosa*. *Eucalyptus socialis* and *Eucalyptus dumosa* are the main mallee species in both landform types occurring on the mapped area.

Ground litter is often high in communities that have remained unburned for some years. Chenopods form an understorey where the soils are higher in clay content, such as on sandplains and swales. *Triodia scariosa* occurs in the understorey on sandier sites such as dune crests. Large woody shrubs such as *Dodonaea*, *Senna* and *Acacia* species are common understorey components in the north-eastern mallee of the mapped area. To stimulate pasture growth, many graziers reduce mallee density by clearing (chaining) and burning (Semple & Eldridge 1989).

Map unit 4: Belah–Rosewood

Structure: low woodland – low open woodland #; open woodland – isolated clumps ##

Main species: *Casuarina pauper* (Belah), *Alectryon oleifolius* subsp. *canescens* (Rosewood). *Alectryon oleifolius* subsp. *elongatus* occurs less commonly; this subspecies has a more eastern distribution and grows on heavier soils (L. Johnson pers. comm., Harden 1990–1992).



Figure 11. Remnant Sandplain Mallee (community 3d) of *Eucalyptus socialis*, *Eucalyptus dumosa* and *Eucalyptus gracilis*, south-west of Hillston along McKinley Road, in mid-spring.



Figure 12. Belah-Rosewood open woodland (community 4) with *Casuarina pauper* in the foreground and a low *Maireana pyramidata* understorey; just west of 'Belgium Park' south of Ivanhoe, at the end of autumn.

Associated species: *Maireana pyramidata*, *Geijera parviflora*, *Exocarpos aphyllus*, *Rhagodia spinescens*, *Acacia victoriae* (B), *Acacia melvillei*, *Dissocarpus paradoxus*, *Maireana sedifolia*, *Myoporum platycarpum*, *Maireana humillima* (B).

Landform: Level to undulating sandplains and aeolian dunes.

Soils: Calcareous earths, mainly of red to red-brown loam to loamy sand. Solonised brown soils to sandy red earths (Cunningham *et al.* 1981). Reddish-brown sands and texture-contrast (duplex) soils (Scriven 1988b). Red-brown soils with light-textured topsoil and calcareous subsoil (Wilson & Johnson 1989).

Occurrence: Belah-Rosewood occurs across the north and in the west to north-west of the Booligal map area (Fig. 12). The densest continuous areas of Belah-Rosewood clumps occur along the Ivanhoe-Balranald Road in the north-west of the map and east of Mossiel along the Alma Lake and East Clare roads. An area of Belah-Rosewood with a low shrubby understorey of *Maireana brevifolia* was observed south of Conoble siding. Scattered trees of *Flindersia maculosa* were also seen within an open Belah-Rosewood community south-east of Ivanhoe. Dense *Casuarina pauper* was also observed in a distinct tier on the lower slopes of Warranary Hill, a rocky outcrop in the far north-east of the Booligal-Hay map (Community 29).

Condition: Scalding and soil erosion, often severe, due to rabbit infestation; many bare areas and trees generally thinned; areas of woody shrubs present; few stands with healthy understorey shrubs; heavily grazed.

Notes: *Casuarina pauper* and *Alectryon oleifolius* are distributed in monospecific groves within this community with little mixing of the two species. Groves or clumps of trees may be many metres apart. An open *Maireana pyramidata* understorey is common, with *Maireana sedifolia* on the calcareous soils at higher elevations. Heavy grazing of these areas has resulted in the thinning and clearing of much of the understorey and the undermining of the sandier soils by rabbits has caused further degradation. The soils are also susceptible to scalding. This community occurs on the westernmost edge of the riverine plain at the transition from alluvial to aeolian landscapes.

Callitris glaucophylla, *Pittosporum phylliraeoides*, *Hakea leucoptera* and *Hakea tephrosperma* occupy sandier areas of higher elevation within this community. *Acacia melvillei* groves are also common on sandy-loam areas. Mallee (Community 3) may intermix with Belah-Rosewood in deeper sands at the western and far north-eastern edges of the mapped area. *Casuarina pauper* and *Alectryon oleifolius* also occur throughout the mapped area as isolated trees or small groves, especially within the mixed *Callitris*-dominated woodlands of prior streams and source-bordering dunes (Communities 16 and 27).

This community is dominated by *Casuarina pauper* which is closely related to, and of a smaller and poorer form than *Casuarina cristata*. Both species were included in Beadle's concept of *Casuarina lepidophloia* (Beadle 1948) and referred to by other authors as *Casuarina cristata* (Cunningham *et al.* 1981). *Casuarina cristata* (Belah) and *Casuarina pauper* (Black Oak) are now treated as distinct species (Wilson & Johnson 1989). An intergrading population of *Casuarina cristata* and *Casuarina pauper* occurs in the east of the mapped area (see Community 28). *Casuarina cristata* is a more central-eastern species in New South Wales and southern Queensland in contrast to the more western distribution of *Casuarina pauper*, which extends across South Australia into Western Australia (L. Johnson pers. comm.).

Tree clumps of *Casuarina pauper* and particularly of *Alectryon oleifolius* often survive by suckering. Regeneration is prevented by grazing (Semple & Eldridge 1989), while the regeneration potential of *Alectryon oleifolius* is also reduced by insect seed-embryo

predation (Wisniewski & Parsons 1986). Belah around Mildura and Ivanhoe is increasingly cut for timber and cleared for cropping, although felling is costly and difficult because of the robust nature of the trees (Semple & Eldridge 1989).

Map unit 8: Black Bluebush

Structure: low shrubland – low open shrubland #; chenopod shrubland – sparse chenopod shrubland ##

Main species:

8. *Maireana pyramidata* (Black Bluebush)

8p. *Maireana pyramidata*, *Maireana sedifolia* (Pearl Bluebush)

Associated species: *Maireana sedifolia*, *Rhagodia spinescens*, *Enchylaena tomentosa*, *Atriplex lindleyi*, *Dissocarpus paradoxus*, *Maireana georgei*, *Stipa nitida*, *Stipa scabra* subsp. *falcata*, *Stipa scabra* subsp. *scabra*, *Eragrostis dielsii*, other *Atriplex* spp. and *Sclerolaena* spp.

Landform: Low sandy rises, undulating plains, lunette remnants, prior stream levees.

Soils: Calcareous sands and loams, red-brown duplex soils with sandy topsoils and clayey subsoils. The distribution of *Maireana pyramidata* and *Maireana sedifolia* appears to be determined by soil calcareousness. Black Bluebush dominates where limestone lies at a depth of 1.2 m or more below the soil surface while soils containing shallower limestone will also support Pearl Bluebush (Beadle 1948).

Occurrence: This shrubland community is common in the north to north-west of the mapped area, particularly on the Booligal map area, where the country becomes undulating and duplex soils predominate (Fig. 13). Smaller rises with *Maireana pyramidata* occur throughout the mapped area, particularly on scalded prior stream levees and flats. Large and often dense areas of *Maireana pyramidata* with *Maireana sedifolia* occur north of Oxley, west of Alma Lake and south of Ivanhoe, although *Maireana sedifolia* does not usually occur as the dominant species in these localities (Fig. 14).

Condition: Severe to moderate soil erosion due to rabbit infestation with many bare areas; severe scalding on source-bordering dunes and lunettes; moderately grazed. Dense, relatively healthy areas exist in the north-west of the mapped area, although these may be periodically subject to caterpillar defoliation and possible dieback.

Notes: This community often grades into *Atriplex vesicaria* or *Atriplex nummularia* on flats and lower areas. Two condition classes of *Maireana pyramidata* were observed within the mapped area. A very open shrubland of scattered, often sparse shrubs occurs on raised scalded areas, lunettes, prior stream levees and cleared areas. Dense continuous stands, often with *Maireana sedifolia*, occur on raised areas with deeper sandy or sandy-loam soils.

Maireana sedifolia (Pearl Bluebush) tends to occur on calcareous soils where limestone nodules lie within 60 cm of the surface and dominates where limestone exists within the first 30 cm (Beadle 1948). *Maireana pyramidata* usually occurs on sandy soils which are alkaline but contain little lime (Dalton 1988). Pearl Bluebush was not mapped as a separate community because of its relatively small extent and has been included under this map unit. The existence of *Maireana sedifolia* within *Maireana pyramidata* shrubland is indicated (map unit 8p). Both species also occur as an understorey to Belah–Rosewood, commonly extending into adjacent areas of this woodland and occasionally into mallee. *Maireana pyramidata* is a common species on the veneer of



Figure 13. *Maireana pyramidata* shrubland (community 8) with a sandhill supporting *Eremophila longifolia* and *Dodonaea viscosa* subsp. *angustissima* in the background; Tchelery Woolshed west of Booroorban, at the end of summer.



Figure 14. *Maireana sedifolia* shrubland (community 8p) with scattered *Casuarina pauper* and *Maireana pyramidata*, west of Alma Lake at the end of autumn.

aeolian material that indicates the transition from riverine or lacustrine landforms. *Maireana sedifolia* becomes the dominant further west where calcareous earths are more common (Beadle 1948, Fox 1991).

The coarse-textured duplex soils supporting bluebush communities are highly susceptible to wind erosion and rabbit infestation. Little clearing of bluebushes occurs in the Western Division because of their drought forage value (Semple & Eldridge 1989). Clearing of dense stands is not permitted under Cultivation Permits issued by the Western Lands Commissioner. This community remains unconserved on the Hay Plain.

Map unit 11: Bladder Saltbush

Structure: low shrubland – low open shrubland #; chenopod shrubland – open chenopod shrubland ##

Main species: *Atriplex vesicaria* (Bladder Saltbush). Due to incomplete distributional data subspecies (Harden 1990–92) have not been recognised in the present survey.

Associated species: *Sclerostegia tenuis*, *Malacocera tricornis*, *Disphyma crassifolium* subsp. *clavellatum*, *Minuria cunninghamii*, *Maireana aphylla*, *Sclerolaena tricuspsis*, *Sclerolaena muricata*, *Ixiolaena tomentosa*, *Eragrostis australasica*, *Sclerolaena brachyptera*, *Sclerolaena bicornis* var. *bicornis*, *Sclerolaena intricata*, *Leptorhynchos panaetioides*, *Calocephalus sonderi*, *Frankenia connata*, *Maireana decalvans*, *Dissocarpus biflorus* var. *biflorus*.

Other common associate species which vary seasonally include:

Atriplex lindleyi, *Atriplex pseudocampanulata*, *Rhodanthe corymbiflora*, *Plantago cunninghamii*, *Podolepis muelleri*, *Daucus glochidiatus*, *Sida trichopoda*, *Maireana pentagona*, *Sclerolaena stelligera*, *Brachycome lineariloba*, *Vittadinia cuneata* var. *cuneata*, *Chloris truncata*, *Sporobolus caroli*, *Agrostis avenacea*.

Landform: Level to depressed alluvial plains.

Soils: Deep, grey, self-mulching and cracking clays to red clay-loam. Grey clays, clay-loams to sandy loams overlying clay (Knowles & Condon 1951). May also occur in sandy deposits.

Occurrence: *Atriplex vesicaria* forms the dominant vegetation community over the mapped area (Figs. 15 & 16). It is believed to have once covered vast areas of the Hay Plain but that excessive grazing has led to its rapid decline (Beadle 1948, Knowles & Condon 1951). Several dieback events over the past decade have seen a further decline in extent of the species. Post-dieback distribution of *Atriplex vesicaria* has been mapped. The largest continuous stands occur north of Hay and west to north-west of Booligal, particularly around One Tree, Oxley, 'Freshwater' and 'Culpataro'. Only small remnant patches exist on the Deniliquin map, these being mainly north of Billabong Creek. The New South Wales Soil Conservation Service established five experimental and regeneration areas on the saltbush plains between 1950 and 1952 which remain fenced today and contain regenerated saltbush (Dalton 1988).

Atriplex vesicaria stands extend west to Balranald and north to about 20 km south of Ivanhoe. The area occupied by Bladder Saltbush stands on the riverine plain was estimated at approximately 1.1 million hectares, decreasing to 0.5 million hectares by the end of 1983 with subsequent dieback (Clift *et al.* 1987). Smaller areas of the community occur further north and west, for example on some of the relict lakes of the Willandra Lakes system. Some saltbush occurs in north-western Victoria as discrete areas along the Murray River (Dalton 1988). *Atriplex vesicaria* shrublands also occur on the treeless plains around the Barrier Range in north-western New South



Figure 15. *Disphyma crassifolium* subsp. *clavellatum* growing amongst *Atriplex vesicaria* shrubs (community 11) south-east of Booligal, in mid-spring.

Wales but, unlike those on the Hay Plain, occur on sandy to sandy loam surface soils (Beadle 1948).

Condition: Seriously affected by widespread dieback; moderately to heavily grazed; shrub densities reduced and many areas degraded to *Maireana aphylla* or copperburr (*Sclerolaena* spp.) shrublands.

Notes: The decline of the once-vast *Atriplex vesicaria* shrublands began with the opening-up of western New South Wales to pastoral activity in the mid-1800s. Overgrazing and drought has seen the elimination of the species over a wide area (Knowles & Condon 1951). In many cases it has been replaced by *Maireana aphylla*, *Sclerolaena* species, annual saltbush species and introduced grasses. Degraded communities within Bladder Saltbush shrubland as listed by Beadle (1948) include *Maireana aphylla*, *Atriplex lindleyi*, *Sclerolaena muricata*, annuals and *Nitraria billardiarei*.

Atriplex vesicaria on the Hay Plain was affected by large-scale dieback from 1977 to 1983 (Clift *et al.* 1987, Clift *et al.* 1989, Semple 1989). This resulted in a 53 per cent decrease in area of the community, from 1 130 000 ha to 531 000 ha (Semple 1989). A second dieback event is presently occurring in these remnant regions (September 1991). The worst-affected areas are south-west to north-west of Booligal with stands directly west of Booligal particularly affected. The causes of these dieback events are discussed in the 'Natural modifications' section of the Discussion.

A close associate of *Atriplex vesicaria* is *Sclerostegia tenuis*, which replaces the former in depressed, saline situations (see Community 12). Large patches of *Eragrostis australasica* often occur in depressions within both these shrubland communities. Bluebush rises often grade into Bladder Saltbush shrubland at lower levels. *Atriplex vesicaria* often occurs mixed with *Atriplex nummularia* on flat to low-lying sites.

Atriplex vesicaria is palatable to sheep and is often the only forage plant available during drought. It is considered highly valuable from a fodder point of view and is high in protein and salt content. The woody stems are brittle and very prone to mechanical damage with overgrazing (Knowles & Condon 1951). Good regeneration of *Atriplex vesicaria* follows high autumn or winter rainfall, however the high temperatures that follow summer rainfall inhibit germination and damage the soil seed source (Knowles & Condon 1951).

Map unit 12: *Sclerostegia tenuis*

Structure: low shrubland #; closed – open chenopod shrubland ##

Main species: *Sclerostegia tenuis* (Slender Glasswort), *Disphyma crassifolium* subsp. *clavellatum* (Round-leaf Pigface).

Associated species: *Atriplex vesicaria*, *Eragrostis australasica*, *Sclerolaena tricuspis*, *Malacocera tricornis*, annual *Atriplex* spp., *Sclerolaena muricata*, *Sclerolaena brachyptera*, *Osteocarpum acropterum* var. *deminuta*, *Minuria cunninghamii*.

Landform: Saline flats and depressions, depressed alluvial plains.

Soils: Clay soils in saline situations.

Occurrence: On depressed saline flats mostly in the west of the mapped area. Large patches occur with *Atriplex vesicaria* around Oxley and 'Corrong' on the Hay map and west of Dry Lake.

Condition: Some dieback apparent; moderately to heavily grazed with many areas degraded to *Maireana aphylla* or copperburr (*Sclerolaena* spp.) shrublands.



Figure 16. Open *Atriplex vesicaria* shrubland (community 11) south of Hay, with annual grass cover of *Hordeum leporinum* and *Lolium perenne*, in early spring.



Figure 17. *Atriplex nummularia* shrubland (community 19) adjacent to Black Box woodland, on 'Mywurlie' station, north-east of Hay, at the end of summer.

Notes: This community is closely allied to *Atriplex vesicaria* shrubland into which it generally grades. *Sclerostegia tenuis* becomes the dominant species in more saline situations and the community is particularly well-developed on the lower alluvium around Lake Victoria and other dry lakes and saltpans further west (Fox 1991). It is considered a highly salt-tolerant species, being capable of colonising highly saline environments where no other species will grow (Beadle 1948). *Sclerostegia tenuis* often forms dense mats below Black Box woodland and has decreased significantly in abundance due to grazing and trampling by stock (Cunningham *et al.* 1981).

Map unit 13: Canegrass

Structure: tussock grassland # and ##

Main species: *Eragrostis australasica* (Canegrass)

Associated species: *Eleocharis pallens*, *Juncus flavidus*, *Juncus aridicola*, *Muehlenbeckia florulenta*, *Disphyma crassifolium* subsp. *clavellatum*, *Chenopodium nitrariaceum*.

Landform: Alluvial plains with depressions and other low-lying areas subject to intermittent flooding or ponding such as swamps, tabledrains and claypans.

Soils: Slightly saline, compact, heavy grey clays.

Occurrence: *Eragrostis australasica* occurs throughout the mapped area. It is particularly common in saline depressions within *Atriplex vesicaria* shrubland north of Hay, on the Lachlan River floodplain between Oxley and Booligal and in tabledrains and depressions along the major roads in low-lying and irrigated areas.

Condition: Some areas cleared, many degraded to copperburr (*Sclerolaena* spp.) shrubland.

Notes: *Eragrostis australasica* tolerates regular, but not prolonged flooding, with *Muehlenbeckia florulenta* (Lignum) occupying the wetter areas (Semple 1990). *Chenopodium nitrariaceum* and *Atriplex nummularia* may be present around the edges of Canegrass swamps.

Areas of *Eragrostis australasica* tend to be small and patchy rather than large and continuous. The species commonly occurs in depressions within the general matrix of *Atriplex vesicaria* or *Maireana aphylla* and these areas have been mapped as composite units (11/13 and 21/13). Much of the Canegrass community was not mapped due to its patchiness and relatively small extent.

Map unit 16: *Callitris* Mixed Woodland

Structure: woodland – low open woodland #; woodland – isolated clumps ##

Main species: *Callitris glaucophylla* (White Cypress Pine). *Callitris gracilis* subsp. *murrayensis* (Murray Cypress Pine) may replace *Callitris glaucophylla* on sandhills and ridges adjacent to the Murray River on the Deniliquin–Bendigo map.

Associated species: *Hakea leuoptera*, *Hakea tephrosperma*, *Alectryon oleifolius* subsp. *canescens*, occasional *Alectryon oleifolius* subsp. *elongatus*, *Acacia melvillei*, *Geijera parviflora*, *Allocasuarina luehmannii*, *Acacia oswaldii*, *Acacia homalophylla*, *Pittosporum phylliraeoides*, *Casuarina pauper*, *Eremophila longifolia*, *Dodonaea viscosa* subsp. *angustissima*, *Senna artemisioides* subsp. *petiolaris*, *Maireana pyramidata*, *Acacia victoriae* (B), *Eucalyptus populnea* subsp. *bimbil* (B), *Eucalyptus intertexta* (B), *Acacia brachybotrya* (D), *Eucalyptus melliodora* (D).



Figure 18. *Callitris glaucophylla* mixed woodland (community 16), north of Gunbar along McKinley Road, in mid-spring.

Landform: Raised sandy areas such as low linear dunes, sandhills, ridges and foot-slopes of rocky outcrops. Old stream beds and levee banks of prior streams and source-bordering dunes formed with the redeposition of prior stream material by wind action (Butler *et al.* 1973). The remnant woodland occupying the major prior streams has been mapped as a separate map unit (see Community 27).

Soils: Coarse-textured red and brown earths such as sandy-loams and loams.

Occurrence: Isolated sandhills with *Callitris* Mixed Woodland occur throughout the mapped area (Fig. 18). Source-bordering dunes associated with prior streams and generally running in an east-west direction occur in the south of the mapped area, notably from west of Boooroorban, through the Tchelery Woolsheds area to just north of Moulamein. Continuous, elevated sandridges also occur north of Conargo and Wanganella. Large areas of *Callitris glaucophylla* occur in Boooroorban, Steam Plains, Puckawidgee, Edgar and Tholobin State Forests and on the properties 'Oolambeyan', 'Gum Creek', 'Steam Plains' and 'Zara'. Unusual areas of *Callitris glaucophylla* with an *Atriplex nummularia* understorey occur on 'Steam Plains' and 'Zara' properties.

Undulating country with remnant *Callitris glaucophylla* is also seen south-west to south-east of Deniliquin in primarily agricultural land, often associated with remnant Grey Box and Bullock woodland (Community 25). *Eucalyptus melliodora*, Yellow Box, is associated with *Callitris glaucophylla* on shallow to deep sandy soils in this area, with Cypress Pine dominating on the sandhills (Moore 1953). *Callitris gracilis* subsp. *murrayensis* may replace *Callitris glaucophylla* on the sandhills and elevated plains adjacent to the Murray River (Fig. 19) and hybrids of these two species may occur. Dense stands of *Callitris glaucophylla* occur within the mallee, Belah-Rosewood and *Casuarina pauper*/*Casuarina cristata* intergrading population, along the eastern edge of the Booligal map. Rocky outcrops seen further north support a different Cypress Pine community, described under map unit 29.

Condition: Severe rabbit infestation and scalding; many areas cleared; trees generally thinned and pine selectively logged in state forests; areas of woody shrubs present; few areas with intact shrubby understoreys; understoreys generally degraded to annual grasslands; little regeneration due to grazing stock and rabbits; areas in the south largely cleared and developed for irrigation; dunes of Murray Cypress Pine within River Red Gum forests of the Murray River floodplain largely cleared.

Notes: Mixed woodland, dominated by *Callitris glaucophylla*, extends from Queensland, throughout the slopes and plains of New South Wales, to Victoria. Associated species vary throughout its range. It occurs throughout the Hay Plain but is seen in its greatest density further east.

This vegetation community shows the most variability of all those sampled. Trees may be widely scattered or may form more or less monospecific groves. *Callitris glaucophylla* in particular tends to occur in large stands with other species scattered or in groves in between. Grove-forming species include *Alectryon oleifolius*, *Acacia melvillei* and *Acacia homalophylla*. An understorey is rare, but where present may include *Maireana pyramidata* and *Rhagodia spinescens*. Much of the original understorey has been grazed out but it is thought that common understorey shrubs may have included species of *Dodonaea*, *Pimelea*, *Rhagodia*, *Exocarpos* and *Senna* (Noble & Mulham 1980). Generally the ground cover consists of short-lived perennial and annual grasses and herbs, many of them introduced species. The sandy soils are highly prone to wind erosion and degradation by rabbits.

Occasionally *Callitris glaucophylla* may be absent from this community, with the associated trees mentioned above dominating. *Acacia victoriae* is occasionally seen as a dominant on slight rises north of Booligal. On the Darling floodplain further west



Figure 19. Roadside remnant woodland of *Callitris gracilis* subsp. *murrayensis*, with *Dodonaea viscosa* subsp. *angustissima* and *Acacia brachybotrya* understorey. Sandhill north of Barham within the River Red Gum floodplain of the Murray River, at the end of winter (community 16).



Figure 20. *Acacia melvillei* clump (community 17) on red, duplex soil west of Alma Lake, in mid-spring, with ground cover of *Rhodanthe floribunda* and *Pycnosorus pleiocephalus*.

are many elevated areas of brown solonized soils which are not subject to flooding and carry open or scattered *Acacia victoriae*, sometimes with *Eremophila sturtii* (Turpentine), *Dodonaea* spp. (Hopbushes), Belah and Rosewood (Stannard 1963).

Some species such as *Dodonaea viscosa* subsp. *angustissima*, *Eremophila longifolia* and *Senna* species can form a dense, low, monospecific scrub within this community. As they reduce the grazing potential of the country, they are locally referred to as 'woody weeds'. Large areas occur along the Booroorban–Tchelery road, in Belah–Rosewood country south-west and south-east of Ivanhoe, and in the mallee between Conoble and Roto.

Early explorers remarked on the Cypress Pine during expeditions into western New South Wales: 'On our way to the river, we passed through some dense bushes of casuarinae and cypresses, to the outskirts of the plains through which the Morumbidgee winds' (Sturt 1833). Once-vast areas of native Cypress Pine between the Murrumbidgee and Lachlan were described by a councillor in 1877 as '... one magnificent pine forest, containing very fine trees and growing amongst them young trees which absolutely denuded the country of grass, but which, if encouraged, would have formed one of the most magnificent forests in the World ... it was destroyed lock, stock and barrel ... today nothing but stretches of land without a pine tree on them ...' (Grant 1989). The greatest destruction of White Cypress Pine occurred between 1880 and 1910, when it was extensively cleared for wheat-growing and ringbarked to provide good grazing lands (Grant 1989). The wood was also utilised for fenceposts and other building materials.

Callitris Mixed Woodland is viewed as being particularly vulnerable in the context of present land use in the area. It is under serious threat from rabbits and stock; even-aged, often old stands of trees are not regenerating due to the grazing out of any seedlings produced. Soil erosion is another problem as the coarse-textured soils are undermined by rabbits and scalded due to lack of a stabilising vegetative cover. This community is not conserved within the mapped area and is considered inadequately so elsewhere.

Map unit 17: *Acacia melvillei* Woodland

Structure: tall shrubland – low woodland #; shrubland to woodland ##

Main species: *Acacia melvillei*

Associated species: *Callitris glaucophylla*, *Acacia homalophylla*, *Acacia oswaldii*, *Alectryon oleifolius* subsp. *canescens*, *Casuarina pauper*.

Landform: Level sandplains, undulating plains and low sandy rises.

Soils: Red-brown clay to sandy loam.

Occurrence: Dense *Acacia melvillei* areas occur between Trida and Wee Elwah in the far north of the Booligal map, north of Gunbar along McKinley Road and north of Moulamein in the south-west. Significant stands were also observed around Ivanhoe, to the north of the mapped area. *Acacia melvillei* forms local communities within *Callitris* Mixed Woodlands (Community 16) of sandy rises and source-bordering dunes throughout the Hay Plain, and within the Belah–Rosewood country of the north-west (Fig. 20).

Condition: Severe to moderate scalding and rabbit infestation; many areas cleared; areas of woody shrubs present.

Notes: This community is generally small in extent or forms localised stands in Belah–Rosewood and *Callitris* Mixed Woodlands. Several larger homogeneous areas have



Figure 21. *Muehlenbeckia florulenta* in Fiddlers Creek south of Maude, with herbaceous banks of *Brassica rapa* subsp. *silvestris*; (community 18); early spring.



Figure 22. *Typha orientalis* and *Typha domingensis* reed-beds in the Lachlan River, south of Oxley, at the end of autumn.

been mapped. *Acacia melvillei* is often mistaken for the very similar species *Acacia homalophylla* which appears to be more common within other communities rather than as a dominant. The two species differ in the number and arrangement of flower heads in the inflorescence (Harden 1990–92). The populations of *Acacia melvillei* around Ivanhoe are cut for domestic firewood (Semple & Eldridge 1989).

Map unit 18: Lignum and *Chenopodium nitrariaceum*

Structure: low shrubland – open scrub #; open – closed shrubland ##

Main species: *Muehlenbeckia florulenta* (Lignum), *Chenopodium nitrariaceum* (Nitre Goosefoot).

Associated Species: *Eragrostis australasica*, *Sclerolaena muricata*, *Juncus flavidus*, *Juncus radula* and other *Juncus* spp., *Senecio cunninghamii* var. *cunninghamii*, *Rumex tenax*, **Rumex crispus*, *Atriplex suberecta*.

Species occurring in wetter areas include *Eleocharis acuta*, **Alopecurus geniculatus*, *Marsilea drummondii* and *Limosella australis*.

Landform: Intermittently flooded channels, depressions, river-flats and swamps. Flooding is relatively infrequent, but often prolonged.

Soils: Heavy grey cracking clays.

Occurrence: This community occurs throughout the mapped region, in bands adjacent to major creeks and rivers and in low-lying swampy areas (Fig. 21), particularly north of Booligal and adjacent to the Murrumbidgee and Lachlan Rivers.

Condition: Large areas cleared for irrigation and grazing; many areas degraded to annual grasslands with *Sclerolaena* spp. (copperburrs); some cropping of depressions and lake beds cropped; some weed infestation.

Notes: *Chenopodium nitrariaceum* exceeds Lignum as the dominant species in this community in occasionally inundated areas with less restricted drainage. It is usually seen forming an understorey to *Eucalyptus largiflorens* and often extends out onto the floodplain beyond the woodland zone to form dense shrublands. It is also common in dry lakes and infrequently flooded depressions. *Muehlenbeckia florulenta* withstands relatively infrequent but more prolonged flooding and may form a dense, almost impenetrable scrub (Semple 1990). It favours channelled plains and depressions with impeded drainage but nearly always occurs with *Chenopodium nitrariaceum*.

Lignum swamp areas are often used for cattle grazing and much has been burned or cleared to promote annual herb and grass growth for feed (Semple 1990). This practice is particularly common in areas adjacent to the Murrumbidgee river west of Hay. This community has also been cleared for irrigation in the Deniliquin region.

Lignum areas provide important wildlife habitat, particularly for waterbirds (Semple 1990). A small area of *Eucalyptus camaldulensis*, *Eucalyptus largiflorens* and *Muehlenbeckia florulenta* (437 ha) is protected in Goonawarra Nature Reserve, south-west of Booligal on the Lachlan River.

Map unit 19: Old Man Saltbush

Structure: low – low open shrubland #; chenopod shrubland – open chenopod shrubland ##

Main species: *Atriplex nummularia* (Old Man Saltbush)

Associated Species: *Rhagodia spinescens*, *Atriplex vesicaria*, *Enchylaena tomentosa*, *Einadia nutans*, *Eucalyptus largiflorens*, *Sclerostegia tenuis*, other *Atriplex* spp.

Landform: Level to depressed plains, low-lying areas and depressions.

Soils: Grey, self-mulching, cracking clays to red duplex soils with grey and brown clays. *Atriplex nummularia* grows on a wide range of soil types and at all levels of the plain (Cunningham *et al.* 1981).

Occurrence: This community occurs throughout the Hay Plain with a patchy distribution. Remnant areas occur around One Tree south of Oxley and west of Booligal. It is found in dry lakes in the north-west of the Booligal map, particularly south of Ivanhoe. Black Box woodlands with an understorey of *Atriplex nummularia* occur between Moulamein and Wanganella, with a particularly dense stand seen on 'Bundy'. This association is often found throughout the mapped area (Fig. 17). *Atriplex nummularia* was once a dominant understorey species to *Acacia pendula* (Beadle 1948, Moore 1953) but this association no longer exists within the mapped area.

Condition: Largely cleared; moderately to heavily grazed with shrubs thinned; some scalding in open areas; little regeneration due to grazing stock, rabbits, goats and kangaroos; some weed and copperburr (*Sclerolaena* spp.) infestation.

Notes: *Atriplex nummularia* was once one of the dominant perennial saltbush species on the Hay Plain (Moore 1953, Leigh & Wilson 1970, Leigh & Mulham 1965). Both *Atriplex vesicaria* and *Atriplex nummularia* were far more abundant before the commencement of pastoral activity in the area but their relative dominance is unknown due to the lack of old records and data. It is believed that both species grew so densely on areas of the Plain as to exclude any other perennial species (Beadle 1948). Evidence suggests that *Atriplex nummularia* was the more common species in the far south-east of the South Western Plains botanical region (Moore 1953).

The mapped areas of Old Man Saltbush are remnants of once-extensive stands that have been subjected to grazing pressure, rabbit-disturbance and clearing. The shrub is palatable to stock and rabbits and recovers well after intermittent grazing, however constant defoliation under heavy grazing pressure is detrimental (Cunningham *et al.* 1981). It was considered an important fodder species before it was grazed out (Beadle 1948). Many small remnants occur around homesteads and in small holding paddocks that saw little grazing. The larger remnant areas are delineated on the maps but many smaller patches exist, often consisting of only scattered individuals.

Maireana pyramidata may occur with *Atriplex nummularia* at transition zones where higher country supporting this species grades off to low-lying areas with *Atriplex nummularia*. This is often seen in undulating country such as that around Oxley and 'Wongalea' east of Gunbar.

Map unit 21: Cotton Bush

Structure: low – low open shrubland #; chenopod shrubland – sparse chenopod shrubland ##

Main species: *Maireana aphylla* (Cotton Bush)

Associated Species: *Atriplex vesicaria*, *Sclerolaena muricata*, *Sclerolaena tricuspidis*, *Nitraria billardierei*, *Minuria cunninghamii*, *Ixiolaena tomentosa*, *Osteocarpum acropterum* var. *deminuta*, *Leptorhynchus panaetioides*, *Atriplex lindleyi*, *Atriplex pseudocampanulata*, *Mala-cocera tricornis*, *Danthonia caespitosa*, *Calocephalus sonderi*, *Sclerolaena bicornis* var. *bicornis*, *Daucus glochidiatus*, **Cotula bipinnata*, *Rhodanthe corymbiflora*, *Rhodanthe pygmaea*,

Plantago cunninghamii, *Podolepis muelleri*, *Calotis scabiosifolia* subsp. *scabiosifolia*, *Brachycome lineariloba*.

Landform: Depressed alluvial plains, usually disturbed.

Soils: Grey to grey-brown clays to clay-loams (Leigh & Mulham 1965).

Occurrence: This community is widespread over the Hay Plain and has proliferated in many areas once dominated by *Atriplex vesicaria* (Fig. 23). The largest continuous stands occur south to south-west of Hay. Dense areas occur within Willandra National Park, north-west of Hillston. *Maireana aphylla* originally occurred with *Atriplex vesicaria* in slightly depressed areas mainly in the east Darling area and excessive grazing has led to its increase with the elimination of *Atriplex vesicaria* over large areas (Beadle 1948).

Condition: Extensive areas degraded to annual grasslands with *Sclerolaena* spp. and *Nitraria billardierei*; weed infestation common; soils often scalded.

Notes: *Maireana aphylla* shrubland is usually grazed or variously disturbed and is considered to be a degraded or disclimax community from Bladder Saltbush shrubland as a result of heavy grazing (Beadle 1948). Shrublands dominated by *Nitraria billardierei*, *Sclerolaena muricata* and *Sclerolaena tricuspidata* indicate greater disturbance. The herbaceous layer within this community consists of short-lived perennial and annual grasses and herbs, many of them introduced. The invasion by exotic pasture species such as *Avena fatua*, *Hordeum leporinum*, *Lolium perenne*, *Phalaris paradoxa*, *Phalaris minor*, *Bromus madritensis*, *Medicago* spp. and *Erodium* spp. has been widespread. These species are indicative of the often disturbed nature of this community.

Maireana aphylla distribution has increased since the *Atriplex vesicaria* dieback of 1977–1983 (Clift *et al.* 1987, Clift *et al.* 1989, Semple 1989). Post-dieback distribution of *Maireana aphylla* has been mapped.

Maireana aphylla and *Nitraria billardierei* tend to occur on slightly depressed areas of the Plain as they are more flood-tolerant than *Atriplex vesicaria* (Beadle 1948). *Maireana aphylla* is often associated with medium to heavy scalding and occasional individuals or patches of remnant *Atriplex vesicaria* may be seen. Shrub cover can vary considerably in this community, ranging from dense monospecific stands to scattered individuals within a matrix comprising annual and short-lived perennial grasses.

Map unit 22: Dillon Bush

Structure: low – low open shrubland #; shrubland – sparse shrubland ##

Main species: *Nitraria billardierei* (Dillon Bush)

Associated Species: *Maireana aphylla*, *Sclerolaena muricata*, *Sclerolaena tricuspidata*. This community occupies disturbed areas and usually comprises a high proportion of introduced and annual species. Other associated species vary depending on the composition of the original vegetation.

Landform: Disturbed low-lying alluvial plains, dry lakebeds.

Soils: Grey to grey-brown clay and loam soils, often saline (Cunningham *et al.* 1981).

Occurrence: *Nitraria billardierei* tends to occur in dense continuous stands in areas of high grazing pressure, particularly adjacent to riverine and box woodlands, and in previously cropped areas. Its distribution has increased markedly with the changed land use in the area since European settlement. Severe overgrazing of the original



Figure 23. *Maireana aphylla* shrubland (community 21) north-west of Deniliquin, with ground cover of *Bromus diandrus* in early spring.



Figure 24. Roadside remnant *Eucalyptus microcarpa* (community 24) with *Acacia hakeoides* understorey; Mooney Swamp Road, north-east of Deniliquin, at the end of winter.

chenopod species has resulted in the establishment of Dillon Bush in areas once occupied by *Atriplex vesicaria* and *Atriplex nummularia* (Noble & Whalley 1978). Dillon Bush commonly occurs in lower densities within other shrubland and woodland communities. The species provides good harbour for rabbits due to its thick and spreading habit.

Map unit 23: Great Cumbung Swamp

This community was not sampled in the current survey and information has been taken from various sources and mapped with reference to Pressey *et al.* 1984.

Structure: closed – open herbland/grassland #; closed – open grassland/rushland/forbland ##

Main species: *Phragmites australis* (Common Reed), *Senecio cunninghamii* var. *cunninghamii* (Bushy Groundsel), *Typha orientalis* and *Typha domingensis* (Cumbung or Bulrush).

Associated Species: **Hordeum leporinum*, **Polypogon monspeliensis*, **Cirsium vulgare*, *Pratia concolor*, *Marsilea drummondii*, *Juncus flavidus*, *Centipeda cunninghamii*, *Persicaria decipiens*, *Paspalum distichum*, **Cotula coronopifolia*, *Eucalyptus camaldulensis*, **Ranunculus sceleratus*, *Cyperus gymnocaulos*, *Vallisneria gigantea*, **Juncus articulatus*, *Potamogeton crispus*.

Landform: Regularly inundated swamp at the confluence of the Murrumbidgee and Lachlan Rivers, with some areas of semi-permanent open water.

Soils: Heavy grey clays.

Occurrence: The Great Cumbung Swamp occurs at the far western edge of the Hay sheet. Areas of *Phragmites australis* and *Typha* spp. may occur throughout the mapped area, wherever there is relatively still, semi-permanent water or in periodically flooded situations. *Typha* spp. are particularly common in marshes, billabongs and creeks with River Red Gum forest or fringing Black Box woodland (Fig. 22).

Condition: River regulation resulting in a reduction in range of the community; some weed infestation.

Notes: Distinct zonation of the main species occurs in the Great Cumbung Swamp. *Typha* species dominate the areas of semi-permanent water with *Phragmites australis* occurring from approximately 0.3 m above the upper *Typha* limit at the periodically flooded lower banks (Pressey *et al.* 1984). *Senecio cunninghamii* var. *cunninghamii* occurs in a broad zone above, and overlapping with *Phragmites australis*. The hydrology of the swamp is influenced by the diversion of water for irrigation from the Murrumbidgee. Natural flooding occurs mainly in spring and summer. The extensive patches of semi-permanent water in the Great Cumbung Swamp can completely dry up during drought periods (Pressey *et al.* 1984).

The Lachlan–Murrumbidgee confluence encompasses other wetland communities besides the Great Cumbung Swamp. It also includes areas of *Eucalyptus largiflorens* and *Eucalyptus camaldulensis*, marshes and lakes on the main floodplain of the Murrumbidgee, and an extensive channelled Lignum area associated with the Murrumbidgee (Pressey 1988). The latter two areas are influenced by water diversions from Redbank and Maude Weirs respectively.

Map unit 24: Grey Box Woodland

Structure: low woodland – woodland #; open woodland – woodland ## (*Eucalyptus microcarpa* occasionally reaches open forest proportions # and ##)

Main species: *Eucalyptus microcarpa* (Grey Box) (D)

Associated Species: *Allocasuarina luehmannii* (Bulloak), *Eucalyptus melliodora* (Yellow Box) (D), *Acacia hakeoides*, *Acacia brachybotrya* (D), *Acacia acinacea* (D), *Callitris glaucophylla*, *Senna artemisioides* subsp. *zygophylla*, *Senna artemisioides* subsp. *filifolia* and *Senna artemisioides* nothosubsp. *coriacea*, *Acacia rigens* (D).

Landform: Level to undulating plains, elevated flats and rises adjacent to the Murray and Edward–Wakool river systems.

Soils: Red-brown earths and heavy clay to loamy alluvial soils (Cunningham *et al.* 1981). Deeper sandy soils to the south-east of Deniliquin (Moore 1953).

Occurrence: *Eucalyptus microcarpa* woodland occurs in the far south of the Hay Plain, restricted to the Deniliquin map sheet (Fig. 24). It is seen from east to south-west of Deniliquin, extending down to the Murray River and has its northern limit on the Plain within the Edward–Wakool river system, where it forms open forest within River Red Gum communities. *Eucalyptus microcarpa* gradually replaces *Eucalyptus largiflorens* south of Deniliquin where it occurs on higher loam soils in association with *Allocasuarina luehmannii* (Bulloak) and *Eucalyptus melliodora* (Yellow Box). Remnant areas occur just north-east of Deniliquin.

Condition: Largely cleared and developed for irrigation; remnant areas prone to weed and rabbit infestation; few remnants with shrubby understoreys intact; little regeneration due to clearing, stock and rabbits.

Notes: *Eucalyptus microcarpa* has been extensively cleared and thinned for both grazing and cropping. Around Deniliquin, this species and *Allocasuarina luehmannii* have been reduced to remnant patches of scattered trees within irrigated agricultural land. Very few areas exist with an intact shrubby understorey, most of these being roadside remnants. Small remnant stands with *Acacia* and *Senna* understoreys exist around Mathoura, north-east of Deniliquin and along Lower Thule Road east of Barham. Taller *Eucalyptus microcarpa* forest occurs with *Eucalyptus melliodora* on the heavy clays within riparian forests. In Werai State Forest north-west of Deniliquin, Aboriginal people cut the bark from the tall *Eucalyptus microcarpa* trees for canoes.

Acacia oswaldii, *Acacia salicina*, *Acacia rigens* and *Eremophila longifolia* have been listed by other authors as associated species (Semple 1990). In the present survey, small areas with *Acacia rigens* and *Acacia oswaldii* were seen along the railway at Burraboi north-west of Deniliquin and along Lower Thule Road east of Barham. *Acacia salicina* was not observed as an associate species.

Beadle mentions already in 1948 that few virgin stands of the woodland exist but that tree densities were once high, having been cleared for wheat growing or thinned for sheep grazing. Shrub species were already inconspicuous then but included *Acacia oswaldii*, *Acacia deanei*, *Acacia hakeoides*, *Acacia rigens*, *Hakea leucoptera*, *Pittosporum phylliracoides*, *Eremophila longifolia* and *Dodonaea viscosa* subsp. *spatulata*. He suggests the herbaceous stratum was probably discontinuous and comprised shade-loving species like *Wahlenbergia gracilis* and *Carex inversa* and perennial grasses such as *Danthonia* spp. (Beadle 1948).

Callitris glaucophylla (Community 16) on sandy to loam rises occurs as a local community within *Eucalyptus microcarpa* woodland east to south-west of Deniliquin. *Allocasuarina luehmannii* and *Callitris glaucophylla* are common associates, occurring on higher

ground above the level of the *Eucalyptus microcarpa*. *Eucalyptus melliodora* is less abundant in this undulating country, observed more often with Grey Box in riparian situations.

Beadle (1948) included *Eucalyptus microcarpa* in his concept of *Eucalyptus woollsiana*, describing the association as a tall woodland with an eastern distribution from around Condobolin to south of Deniliquin. Grey Box is described as occurring either in pure stands or in association with *Callitris glaucophylla* or *Eucalyptus populnea* subsp. *bimbil* (Bimble Box), a community which is presently more common east of the Hay Plain. The soils are red-brown earths, sometimes a sandy loam but usually a loam or clay-loam overlying a clayey subsurface soil with lime occurring in varying quantities throughout the profile. Yellow Box is mentioned as an associated species while *Callitris glaucophylla* is present as a lower tree layer. *Allocasuarina luehmannii* forms local societies within Grey Box (Beadle 1948). The Grey Box Woodland of the current survey also appears to be synonymous with the *Eucalyptus woollsiana* and *Callitris glaucophylla* association identified by Moore (1953) where *Allocasuarina luehmannii* is described as a subsidiary species in the tree stratum.

Map unit 25: *Acacia pendula* Woodland

Structure: low – low open woodland #; open woodland – woodland ##

Main species: *Acacia pendula* (Myall or Boree)

Associated Species: *Rhagodia spinescens*, *Atriplex nummularia* (largely cleared), *Danthonia caespitosa*, *Maireana aphylla*, annual *Atriplex* spp., annual and short-lived perennial grasses, **Medicago* spp., *Enchylaena tomentosa*, *Atriplex semibaccata*, *Maireana decalvans*, *Stipa nodosa*.

Amyema quandang subsp. *quandang* commonly occurs as a parasite on *Acacia pendula* but the mistletoe rarely kills the host (Beadle 1981).

Other common associate species which may vary seasonally or with grazing pressure include *Alternanthera denticulata*, *Centipeda cunninghamii*, *Sida* spp., *Rhodanthe corymbiflora*, *Maireana pentagona*, *Sclerolaena stelligera*, *Erodium* spp., *Myriocephalus rhizocephalus* subsp. *rhizocephalus*, **Cotula bipinnata*, *Vittadinia cuneata* var. *cuneata*, *Lepidium pseudohyssopifolium*, *Enteropogon acicularis*, *Ranunculus* spp.

Landform: Level to depressed plains. Adjacent to streams or in depressions in grasslands (Beadle 1981).

Soils: Grey and brown clays and more rarely on red-brown earths (Beadle 1981, Semple 1990).

Occurrence: *Acacia pendula* occurs mainly in the east of the Hay Plain and is seen here at the western limit of its range (Fig.25). The densest stands occur east of Hay along the Gum Creek–Conargo Road, along Wrights Lane south-east of Gunbar, east to north-east of Conargo and south of Hillston along McKinley Road. Isolated groves and scattered trees occur within *Danthonia caespitosa* (Community 26), *Eucalyptus largiflorens* (Community 2) and lower areas within *Casuarina pauper*/*Casuarina cristata*-intergrade woodland (Community 28) in the eastern sector of the Plain. Roadside remnants exist in agricultural country around Deniliquin and Hillston.

Condition: Widely cleared or thinned with extensive areas degraded to annual grasslands; moderate scalding and rabbit infestation; some areas of woody shrubs present; weeds common; few areas with shrubby understoreys; understoreys generally degraded to annual grasslands; little regeneration due to grazing.



Figure 25. *Acacia pendula* open woodland at the end of summer (community 25), with *Rhagodia spinescens* and grassy understorey; Jerilderie Road, south-east of Hay.

Notes: Widespread clearing of *Acacia pendula* for cropping, fodder and timber has resulted in a patchy remnant distribution. It commonly occurs with a very open structure and a herbaceous understorey, mostly comprising **Medicago* spp. and grasses such as *Danthonia caespitosa*, *Enteropogon acicularis*, **Lolium perenne*, **Hordeum leporinum*, **Vulpia myuros* and **Bromus madritensis*. A shrubby understorey is rare or lacking. The original *Atriplex nummularia* understorey has been largely cleared. Moore (1953) noted remnants as existing in the Jerilderie area. *Atriplex vesicaria* and *Maireana aphylla* are also listed as original understorey components with the latter persisting over the two species (Beadle 1981). There are few tree associates but where present may include *Acacia salicina* and *Acacia oswaldii* (Beadle 1981).

The disappearance of the *Acacia pendula*-*Atriplex nummularia* alliance is attributed mainly to heavy sheep grazing followed by the severe drought of 1875 to 1877 (Moore 1953). *Acacia pendula* was felled for stock feed and regeneration was prevented by stock and rabbit grazing. The *Danthonia caespitosa* grassland areas are believed to be disclimax communities which once carried the *Acacia pendula*-*Atriplex nummularia* association (Beadle 1948, Moore 1953). Perennial grasslands still support a wide range of native plants including rare species such as *Swainsona plagiotropis* (see Table 5). Scattered *Acacia pendula* occurs within the mapped *Danthonia caespitosa* grasslands (see Community 26) lending support to this disclimax theory. None of this association exists within the mapped area today, with the only known stands remaining on two merino properties west of Jerilderie; 'Coonong' and 'Coree' (Moore 1953).

Acacia pendula woodland is a vulnerable vegetation type and is not represented in any conservation reserve in south-western New South Wales (Brickhill 1985). Unlike most *Acacia* species, *Acacia pendula* fruits and sets seed sparingly and seed germination is poor (Beadle 1981). The foliage is readily eaten by stock and any seedlings produced are prone to grazing or trampling. Rabbits may also undermine the root systems in lighter clay soils.

Map unit 26: White-top Grassland

Structure: tussock grassland – open tussock grassland #; grassland – open grassland ##

Main species: *Danthonia caespitosa* (White-top or Ringed Wallaby Grass) predominantly, but there is usually a *Danthonia eriantha* component of about 10 per cent (S. Jacobs, Royal Botanic Gardens, pers. comm.).

Associated Species: *Chloris truncata* (Windmill Grass), *Enteropogon acicularis*, *Sporobolus caroli*, *Bromus arenarius*, *Stipa nodosa*, **Hordeum leporinum*, **Lolium perenne*, **Lolium rigidum*, **Avena fatua*, **Bromus madritensis*, **Vulpia myuros*, **Medicago* spp., **Erodium* spp., *Rhodanthe corymbiflora*, *Sida trichopoda*, *Sida corrugata*, *Maireana aphylla* (occasionally).

Landform: Level alluvial plains.

Soils: Grey to brown clays or clay-loams, usually with a compacted surface (Beadle 1948).

Occurrence: This grassland is composed of short-lived perennial and annual grasses and occurs in the east to south-east of the Hay Plain, extending from north-east of Deniliquin to south of Gunbar. The most homogeneous areas are found south-east to north-east of Hay (Fig. 26).

Condition: Moderately to extensively grazed with many areas degraded to annual grasslands.



Figure 26. Dried-off grassland of *Danthonia caespitosa* (community 26) at the end of summer, north of Carrathool in the far east of the Hay Plain.



Figure 27. *Callitris glaucophylla* regenerating on prior stream (community 27), within an enclosure on 'Walgrove', south-east of Hay, at the end of summer.

Notes: Previous records and surveys suggest that *Danthonia caespitosa* grassland is a degraded or disclimax community that has developed under heavy grazing from climax communities dominated by *Acacia pendula*–*Atriplex nummularia* (Moore 1953) or *Atriplex vesicaria* (Beadle 1948). According to Beadle (1948) *Atriplex vesicaria* once occurred in areas now carrying grasslands (*Chloris*–*Danthonia* association) and *Maireana aphylla*. When the shrub phase is removed by grazing, perennial grasses such as *Danthonia* and *Chloris* remain; they in turn can be grazed out, leaving annual grasses and annual or short-lived spiny-fruited chenopods (S. Jacobs pers. comm.). In a study concentrating on the grasslands around Jerilderie, Narrandera and Urana to the east of the study area, Moore (1953), suggests that these grassland areas once carried *Acacia pendula* and *Atriplex nummularia* with *Atriplex vesicaria*. *Acacia pendula* remnants currently exist in the mapped grasslands, but no *Atriplex nummularia* and little *Atriplex vesicaria*.

Danthonia caespitosa may dominate the ground layer in *Eucalyptus largiflorens*, *Acacia pendula* and other woodland communities. Short-lived perennial and annual grasses dominate the pasture in more disturbed communities with a seasonal composition. Common species include **Hordeum leporinum*, **Lolium perenne*, **Avena fatua* and **Bromus madritensis*. At various times of the year **Medicago* spp., **Erodium* spp. and other herbs (commonly Asteraceae) are a significant component of the ground layer.

Where grazing is not too severe, *Danthonia caespitosa* will seed and recruit regularly (Cunningham *et al.* 1981). The species may be eliminated with heavy, continuous grazing and replaced with *Chloris truncata* and annual grasses. Severe grazing pressure and disturbance can lead to the removal of *Chloris truncata*, resulting in a herb-field or grassland comprising annual species (Beadle 1948).

The grassland areas south-east of Hay were affected by wildfires in November 1990. A large area of *Danthonia caespitosa* grassland was burned and much of it has not regenerated as at October 1992, but has been replaced by other grass and herb species. The grassland distribution prior to the fire has been mapped.

Map unit 27: Prior Stream Remnant Woodland

Structure: low open woodland #; open woodland - isolated trees ##

Main species: *Callitris glaucophylla* (White Cypress Pine), *Hakea leucoptera* (Needlewood), *Hakea tephrosperma* (Hooked Needlewood).

Associated Species: *Pittosporum phylliracoides*, *Alectryon oleifolius* subsp. *canescens*, occasional *Alectryon oleifolius* subsp. *elongatus*, *Rhagodia spinescens*, *Stipa scabra* subsp. *scabra*, *Aristida behriana*, *Enneapogon nigricans*, **Cucumis myriocarpus*, *Wahlenbergia stricta* subsp. *stricta*.

Landform: Raised beds of prior streams indicated by low, winding sandy ridges on the clay floodplain (Butler *et al.* 1973).

Soils: Gravel, sand and sandy-loam overlying clay (Butler 1950).

Occurrence: Prior streams occur mainly east to south-east of Hay within the mapped area although they are seen more frequently south and west of Griffith (Schumm 1968). Large prior streams run through 'Walgrove' property (Fig. 27), Wrights Lane and Murrumbidgee River Road north-east of Hay. Several are also seen north of Conargo.

Condition: Largely cleared; severe scalding and soil erosion due to rabbit infestation; little regeneration due to grazing stock and rabbits.



Figure 28. Woodland of *Casuarina pauper*/*Casuarina cristata* intergrades (community 28) with *Apophyllum anomalum* (Warrior Bush) in the left-foreground; north-east of Gunbar in mid-spring.

Notes: This vegetation community is of a very remnant nature, often reduced to just several scattered trees or a small grove. Prior streams are not always obvious on the ground and are usually visible as a line of scattered trees on a low narrow rise with adjacent scalding. Isolated groves of *Hakea* spp. or *Pittosporum phylliracoides* may also indicate the existence of a prior stream. The stream trace is continuous and well-defined on aerial photos.

As well as *Callitris glaucophylla*, *Hakea* spp. and *Alectryon oleifolius*, prior streams once supported stands of *Acacia homalophylla*, *Casuarina pauper* and *Geijera parviflora* (Semple 1987a).

Prior streams are the last of a series of alluvial systems deposited on the Plain during late Pleistocene times and functional up till Recent times (Butler 1950). They have been mapped to include the elevated stream bed and associated scalded levees. The dunes range in height from 3 to 15 metres (Semple & Eldridge 1989).

Map unit 28: *Casuarina pauper*/*Casuarina cristata* Intergrading Population

Structure: low woodland – woodland #; open woodland – woodland ##

Main species: *Casuarina pauper*/*Casuarina cristata* intergrades

Associated Species: *Geijera parviflora* (Wilga), *Exocarpos aphyllus* (Leafless Cherry), *Apophyllum anomalum* (Warrior Bush), *Alectryon oleifolius* subsp. *canescens*, occasional *Alectryon oleifolius* subsp. *elongatus*, *Maireana georgei* (Satiny Bluebush), *Rhagodia spinescens*, *Enchylaena tomentosa*, *Maireana decalvans*, *Maireana pyramidata*, *Atriplex stipitata*, *Sclerolaena birchii*, *Zygophyllum glaucum*.

Landform: Flat to gently undulating plains, largely aeolian.

Soils: Texture-contrast soils of brown to red-brown sandy loam to loam, overlying red to red-brown clays.

Occurrence: This intergrading population occurs in a localised area between Gunbar and Hillston, along the central-eastern edge of the mapped area (Fig. 28). It extends from south-west of Gunbar through to south-west of Hillston. The densest continuous stands occur north of Gunbar on level to slightly undulating plains along McKinley, Booligal, Gunbar and Old Gunbar Roads.

Condition: Many areas cleared but remnants generally dense and with understorey shrubs present; some rabbit and weed infestation.

Notes: This community is dominated by intergrades of *Casuarina pauper* with *Casuarina cristata* (L. Johnson pers. comm.) which are taller in habit than *Casuarina pauper* and with a denser crown. *Casuarina pauper* is the co-dominant species in the Belah-Rosewood country seen further west on the deeper sandier soils of the aeolian-fluviatile transition zone (see Community 4). *Casuarina cristata* has a more eastern distribution, occurring in a north-south band from south-eastern Queensland to the south-western slopes of New South Wales (L. Johnson pers. comm., Wilson & Johnson 1989). This intergrading population falls between the distribution of *Casuarina pauper* on the deeper red-brown sands further west (see Community 4), and *Casuarina cristata* on clayey grey or brown soils containing surface calcium (Wilson & Johnson 1989). The sandsheet supporting the intergrading community overlays a clay subsurface soil.

The main associate species in this community are *Geijera parviflora*, *Exocarpos aphyllus* and *Apophyllum anomalum*, with Rosewood uncommon and usually restricted to small

groves or isolated trees. *Maireana georgei* (Satiny Bluebush), *Enchylaena tomentosa* and *Rhagodia spinescens* dominate the understorey in this woodland, while *Maireana pyramidata* is more prevalent in the Belah-Rosewood communities further west. A *Maireana pyramidata* association with *Maireana georgei* is said to occur mainly on soils that have not been seriously eroded (Stannard 1963). *Maireana georgei* is also noted here as having increased in number in certain sites in recent years.

This community is often somewhat mixed with a mosaic of *Callitris glaucophylla* woodland, open mallee and *Acacia pendula* woodland, especially north of Gunbar along the eastern edge of the mapped area. *Eucalyptus largiflorens* and *Acacia pendula* occur in low-lying areas whilst *Callitris glaucophylla*, *Hakea* species and groves of *Acacia melvillei* dominate the sandier rises within this community.

Map unit 29: Rocky Outcrop Woodland Complex

Structure: low woodland #; woodland to open woodland and open mallee woodland – shrubland ##

Main species: *Callitris glaucophylla* (White Cypress Pine) and *Eucalyptus intertexta* (Western Red Box) (B) throughout; *Eucalyptus vicina* (B) and *Brachychiton populneus* subsp. *trilobus* (Kurrajong) (B) on the summit; *Casuarina pauper*, *Alectryon oleifolius* subsp. *canescens* and *Eremophila mitchellii* (Budda) (B) on the lower slopes.

Associated Species: *Geijera parviflora* and *Exocarpos aphyllus* on lower slopes; *Pandorea pandorana* (Inland Wonga Vine) (B), *Dodonaea lobulata* (B), *Cheilanthes austrotenuifolia* (Rock Fern) (B), *Pleurosorus subglandulosus* (B), *Thysanotus patersonii* (Twining Fringe Lily) (B) and *Arthropodium minus* to summit; *Beyeria viscosa* (B) and *Actinobole uliginosum* at summit.

Landform: Footslopes, ridges and crests of low rocky outcrops. Low relief erosional rocky outcrop of sandstone-conglomerate geological type (Norris & Thomas 1991). Bevelled and rounded hills with rocky cliffs of quartzite, sandstone and conglomerates (Walker 1991).

Soils: Brown to red-brown clay-loam to sandy loam with surface stones and gravel, overlying a sandstone-conglomerate substrate. Sandstone lithosols to red earths comprising shallow sands, loams and clay-loams, with a stony or gravelly surface (Norris & Thomas 1991).

Occurrence: Warranary Hill in the Warranary Range, north-west of Roto in the far north-east of the Booligal map (Fig. 30). This is the only rocky outcrop that exists within the mapped area and as such this vegetation community is not typical of the Hay Plain.

Condition: Moderate to severe rabbit infestation and grazing and trampling by goats.

Notes: There is a distinct zonal distribution of species from the footslopes to the summit of the outcrop. Mixed *Callitris glaucophylla* and Belah-Rosewood, with *Geijera parviflora* and *Exocarpos aphyllus* dominate the footslopes. A distinct *Casuarina pauper* zone occupies the lower slopes with *Dodonaea lobulata* and *Eremophila mitchellii*. *Callitris glaucophylla* dominates from the middle slopes to the crest, with *Eucalyptus intertexta* coming in on the upper rocky slopes and ridges. Mixed *Callitris glaucophylla* and *Eucalyptus intertexta* persist to the top where *Eucalyptus vicina* (Fig. 29) and scattered *Brachychiton populneus* appear, constituting a mixed summit woodland.

Other potential associate species within this complex were recorded for a site of similar geological type in the Keginni Range further north (Norris & Thomas 1991).



Figure 29. *Eucalyptus vicina* and scattered *Callitris glaucophylla* on the rocky summit of Warranary Hill (community 29), north-east of Roto in mid-spring.



Figure 30. Warranary Hill north-west of Roto, with *Callitris glaucophylla* from footslopes to summit, and *Casuarina pauper* on lower slopes; (community 29); mid-spring.

These include *Acacia aneura* (Mulga), *Acacia doratoxylon* (Currawang), *Acacia decora* (Western Golden Wattle) and *Cheilanthes austrotenuifolia* (Rock Fern). Other species recorded for the site by the same authors include *Pleurosorus rutifolius*, *Calotis cuneifolia*, *Calotis hispidula*, *Sigesbeckia australiensis*, *Stuartina muelleri*, *Geococcus pusillus*, **Silene gallica*, **Stellaria media*, **Chenopodium murale*, *Fimbristylis dichotoma*, *Phyllanthus fuernrohrrii*, **Medicago laciniata*, *Gonocarpus elatus*, *Isotoma axillaris*, *Eucalyptus vicina*, *Eucalyptus morrisii*, *Eragrostis lacunaria*, **Lamarckia aurea*, *Thyridolepis mitchelliana*, *Eriostemon linearis* and *Hybanthus monopetalus*.

Walker (1991) describes the vegetation of Warranary Hill. *Callitris glaucophylla*, *Eucalyptus intertexta*, *Acacia aneura*, *Senna* species and various grasses and forbs occur throughout. *Eucalyptus morrisii*, *Acacia doratoxylon*, *Eriostemon linearis* (Narrow-leaf Waxflower) and *Eremophila serrulata* (Green Fuchsia Bush) occupy the crests and upper slopes, with *Eremophila mitchellii*, *Eriostemon linearis* and *Pandorea pandorana* on the lower slopes. *Eucalyptus populneus* subsp. *bimbil*, *Acacia decora*, *Dodonaea viscosa* subsp. *angustissima* and *Eremophila sturtii* are seen along drainage lines.

Rocky outcrops tend to receive little grazing due to their relative inaccessibility to stock. Feral goats, however, are a major problem in rocky areas, causing much damage in high numbers by grazing and trampling native vegetation. Rabbits are also a problem in the sandier soils of the footslopes where they undermine root systems and cause massive soil erosion. Both goats and rabbits were observed on Warranary Hill.

Open Areas (OA)

These are highly disturbed areas with a vegetation cover of annual or short-lived perennial grasses, herbs, forbs and few shrubs. Open Areas result from intense grazing, clearing and fire. Introduced pasture species usually predominate such as **Hordeum leporinum*, **Lolium perenne*, **Avena fatua* and **Medicago* spp. The composition of annual species changes seasonally but may also include *Erodium* spp., asteraceous herbs such as *Rhodanthe corymbiflora*, **Cotula bipinnata* and *Podolepis muelleri*, annual saltbushes and *Swainsona* species. Weeds may also dominate the more disturbed Open Areas such as road verges and heavily used paddocks. Infestations of **Echium plantagineum* (Patterson's Curse), **Arctotheca calendula* (Capeweed) and **Brassica* spp. are particularly common on the Hay Plain.

Cleared Areas (C)

These areas have been almost entirely cleared of natural vegetation and often cultivated for agricultural purposes. Intensive irrigation farming on the Murray River and Edward-Wakool floodplains has led to almost complete clearing of native woodlands, shrublands and grasslands in these areas. Much of the cleared country north of the Murray River contains remnant stands of *Callitris glaucophylla*, *Eucalyptus microcarpa* or *Acacia pendula* that have been cropped right up to the trees. Larger areas of these remnant trees have been mapped but are essentially a cleared unit. Remnants are indicated in brackets after the C symbol.

Floristic Composition

A species list for the mapped area compiled from the current survey and published lists is given in Appendix 1. A total of 383 species from 68 families were recorded for the mapped area during the present survey. The number of species recorded for the

riverine plain as a whole rises to 977 if previous surveys are included. Leigh and Mulham (1977) reported many aquatic and escapee species not recorded for the present survey, while other surveys concentrated on particular habitats such as riparian situations (Margules & Partners *et al.* 1990). The record is dominated by species from the Poaceae (150 species or 15 %), Asteraceae (150 species or 15 %), Chenopodiaceae (83 species or 9 %) and Fabaceae (74 species or 8 %). A large proportion of species recorded are exotic: 21 per cent from the present survey, a figure which rises to 40 per cent including other records.

Several extensions of range were recorded during the survey for a number of species (Appendix 1). Four species are new records for the South Western Plains botanical subdivision while ten are unsubstantiated new records for New South Wales (Jacobs & Pickard 1981, Harden 1990–92). Twenty-seven taxa have not been recorded in any previous survey on the Hay Plain, although many of these were recorded from mallee and rocky outcrop communities atypical of the vegetation of the Plain. Fifteen of the species recorded have restricted distributions in the Western Division of New South Wales (Pressey *et al.* 1990) while eight are listed as rare, vulnerable or endangered, and one species as extinct (Briggs & Leigh 1988) (Table 5).

The composition of annual and short-lived perennial species varies from year to year and most of them are widespread and not specific to any particular community. Species turnover between seasons in arid communities is considerable, and seasonal samples only represent a fraction of the total species richness (Fox 1990). *Callitris* Mixed Woodland (Community 16) showed the highest species variability of all communities sampled on the Plain, because of the many associated trees and shrubs. Grove-forming species such as *Alectryon oleifolius*, *Acacia melvillei*, *Senna* spp. and *Dodonaea* spp. often form localised communities. Mallee areas exhibited considerable variability in understorey species associated with small-scale changes in soils and geomorphology. Many of the tree-dominated communities showed some degree of structural variability. *Eucalyptus camaldulensis* exhibits both open forest and woodland proportions while *Eucalyptus microcarpa* may attain forest dimensions within riparian situations. Mallee species that have low and multi-stemmed growth forms in mallee shrublands may elsewhere be tall and single-stemmed, forming woodlands.

Discussion

Distribution of the vegetation communities

The major cause of variation in vegetation type is an interaction between soil moisture and rainfall, in particular depth of wetting (Noy-Meir 1974). With the move from sandy to clayey soils the moisture regime changes from one of deeper, easily available moisture to shallow, marginal moisture. The associated vegetation communities have adapted to each of these regimes. Most annual species die once the temporary topsoil water is depleted, but as long as it persists, the faster root and shoot growth of annual species gives them the competitive advantage over the perennials. As the depth of wetting increases, the competitive advantage shifts from shallow-rooted to deep-rooted species.

Soil fertility, particularly in phosphate, may be a secondary factor determining vegetation composition (Noy-Meir 1974). *Maireana sedifolia* dominates on calcareous soils where limestone nodules exist within the first 30 cm of the surface (Beadle 1948). *Atriplex vesicaria* grows in grey clays which are mildly alkaline and contain calcium carbonate (Beadle 1981).

Fluvial influences

The alluvial landscape dominates the Hay Plain, with some minor lacustrine elements. The characteristic vegetation communities are the various chenopod shrublands, notably *Atriplex vesicaria* shrubland, as well as the *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* woodlands that fringe the rivers and creeks and extend out across the lower floodplains.

The grey clay soils of the Plain support different vegetation communities at different levels. The lowest, most water-retaining floodplains and depressions carry *Muehlenbeckia florulenta* scrub, *Eragrostis australasica*, *Eucalyptus camaldulensis* forest and other species tolerant of regular inundation. *Eucalyptus largiflorens* woodlands and *Chenopodium nitrariaceum* shrublands are found at slightly higher levels on the floodplain. The slightly elevated brown clay plains adjacent to the Murray River south of Deniliquin carry *Eucalyptus microcarpa* and *Allocasuarina luehmannii* remnants. These were some of the first areas to be cleared and cropped due to the fertile soils and their proximity to an irrigation source. Relatively large and dense areas of River Red Gum forest occupy the wide floodplains directly adjacent to the Murray River.

Saltbush (*Atriplex*-dominated) shrublands occur on the level, slightly saline plains and exist within the mapped area at their eastern and southern limits. Areas that receive water run-on usually have deeply cracking clays which give deep rooting species like *Atriplex nummularia* a moisture advantage (Dalton 1988). Remnant shrublands of this species are thus found on lower lying areas of the Plain. More compact clays which have a shallower wetting profile give shallow rooting perennial species such as *Atriplex vesicaria* the competitive advantage. *Atriplex vesicaria* and *Maireana aphylla* shrublands dominate the vast level plains, with *Sclerostegia tenuis* growing in more saline situations. These communities show varying degrees of degradation and most comprise often large areas of species indicative of disturbance such as *Nitraria billardiieri*, *Sclerolaena muricata* and *Sclerolaena tricuspidis*. The area supporting *Atriplex vesicaria* was certainly much greater prior to grazing, which has allowed the spread of more competitive species such as *Maireana aphylla* where the saltbush has been removed or thinned.

Acacia pendula woodland is also found on alluvial plains, occupying level to depressed grey clay plains or red-brown earths at slightly higher levels on the floodplain. It occurs within the mapped area at its western limit in south-western New South Wales. In this lower rainfall zone it occurs on heavier clay soils which retain moisture better while further east the surface soils supporting *Acacia pendula* are loamier (Moore 1953). Heavily grazed areas in the east of the mapped area which once supported *Atriplex vesicaria*, *Acacia pendula* and *Atriplex nummularia* are now disclimax perennial grasslands or, where grazing pressure continues to be high, annual grasslands comprising introduced pasture species (Moore 1953, Beadle 1948, Wilson & Graetz 1979).

Prior stream remnants which take the form of low oval-shaped dunes and old raised stream beds, provide minor topographic relief to the alluvial landscape. The coarser textured soils of these landforms carry mixed *Callitris*-dominated woodlands and *Maireana pyramidata* shrublands and are highly vulnerable to degradation due to the erodible nature of the soils. Rabbits are a particular problem in these sandier areas as the soil provides much better burrowing conditions, compared to the more compact clays of the surrounding plains.

Aeolian influences

The aeolian sandsheets predominating in the west and north of the Hay Plain mark the transition from fluvial to aeolian landscapes. Major changes in the vegetation

occur here, as Belah–Rosewood open woodland and mallee and bluebush shrublands replace the low, uniform chenopod shrublands and grasslands of the alluvial plain. Aeolian forces also shape minor elements on the alluvial plain itself. An indicator of aeolian influences and sandier soils on the alluvial plain is the presence of *Callitris glaucophylla*, *Hakea* species and other mixed woodland species (Beadle 1948). While their presence may indicate the existence of a prior stream bed, larger rises supporting these species may be source-bordering dunes comprising the coarser soils of prior streams redeposited by wind action (Butler *et al.* 1973). *Callitris glaucophylla* occurs extensively on deeper, sandy soils and on rocky outcrops further north to north-east. Lunettes and scalded plains supporting bluebush shrublands are also geomorphological features with aeolian origins. The soils of aeolian landforms tend to be coarse-textured and are susceptible to erosion once the fixing vegetation cover is removed (Semple & Eldridge 1989).

Small areas of mallee encroach on the mapped area and are primarily of the sandplain type with a shrubby understorey, although some dune-crest mallee carrying *Triodia scariosa* occurs in the north-east. Much of this mallee is of the multi-stemmed 'whipstick' form indicating lower soil fertility and a history of regular burning (Beadle 1948, Noble *et al.* 1980). Remnants of large, old trees of the 'bull' mallee form are seen in heavily cleared areas along the north-eastern and western edges of the mapped area. Dunefields supporting mallee vegetation are more typical of the aeolian country to the west and north-east of the Hay Plain.

More typical of the aeolian landscape within the mapped area are open woodlands of *Casuarina pauper* (Belah) and *Alectryon oleifolius* (Rosewood) and *Maireana*-dominated shrublands. These dominate the sandsheets in the north to north-east of the Plain. *Maireana pyramidata* shrubland is a common community on the transition zone between aeolian country and alluvial plains and on the source-bordering dunes associated with prior streams. The duplex soils have a sandy topsoil 0.3 to 1 m thick, overlying an alluvial clay base (Semple & Eldridge 1989). Where limestone exists close to the soil surface *Maireana sedifolia* (Pearl Bluebush) dominates, and it becomes the dominant bluebush in the more calcareous earths further north and west (Beadle 1948). On the aeolian sandplains, in areas with low to medium grazing pressure, *Maireana pyramidata* forms the understorey to Belah and Rosewood. Belah–Rosewood is cleared preferentially to mallee and is prone to invasion by woody shrubs such as *Dodonaea viscosa* subsp. *angustissima* and *Senna* species.

Both mallee and Belah–Rosewood occur more extensively north of the mapped area with Belah–Rosewood dominating to the north-west and mallee to the north-east. *Acacia melvillei* is an important component of the aeolian landscape and commonly occurs in groves on sandier sites within Belah–Rosewood areas. Across the Hay Plain, groves of either Belah, Rosewood or both species occur within mixed woodlands on low sandy rises. Of particular interest in the central east of the mapped area is a sandsheet comprising duplex red-brown earth overlying clay supporting an intergrading population of *Casuarina pauper* with *Casuarina cristata* (Community 28).

Seasonal variability of the vegetation

The composition of annual and short-lived perennial grasses and herbs in open understoreys and pastures, varies considerably from season to season. Most of the winter and spring herbage comprises escaped pasture and other exotic species which are widespread throughout most vegetation communities. **Hordeum leporinum* (Barley Grass) is the most widespread and abundant grass species, especially after autumn rains but **Lolium perenne*, **Avena fatua*, **Bromus madritensis* and **Phalaris* species may become local dominants. *Medicago* species are also extremely abundant and wide-

spread with burrs persisting throughout the driest periods. Both introduced and native species of *Erodium* are also common. Native annual species are also present in the flux of grasses and herbs that occurs after autumn and winter rains. *Rhodanthe corymbiflora*, *Rhodanthe floribunda*, *Podolepis muelleri*, *Daucus glochidiatus*, *Brachycome lineariloba*, *Pycnosorus pleiocephalus*, *Daucus glochidiatus*, *Swainsona procumbens*, and species of *Vittadinia*, *Wahlenbergia*, *Ptilotus* and *Goodenia* are some of the more showy species. Annual saltbushes such as *Atriplex lindleyi*, *Atriplex conduplicata*, *Atriplex pseudocampanulata* and *Atriplex leptophylla* are also a common component of the springtime herb layer in many communities.

The availability of water is the major climatic limit to plant growth on the Hay Plain. Temperature is also important in that it directly affects evaporation and transpiration. Winter is generally the period most favourable for plant growth, more so in the south where annual rainfalls are higher and more reliable. Most annual species grow in the winter months under these more favourable moisture regimes while summer growing and long-lived perennial species have developed strategies to either tolerate or avoid drought. Perennial *Atriplex* species require relatively little moisture for continued survival and growth. The high concentration of soluble salts in the plants and fine leaf hairs facilitate water absorption and prevent water loss during dry periods (Knowles & Condon 1951). Annual and short-lived perennial species are able to evade the hotter months and drought by completing their life cycle after one reasonably heavy fall of rain. Perennial shrubs such as *Atriplex vesicaria*, *Atriplex nummularia*, *Chenopodium nitrariaceum* and *Maireana aphylla* depend to a large extent on winter rains for germination and establishment (Dalton 1988).

The abundant annuals produced during winter, as well as some perennial grasses, die off in late spring to persist as dried stubble or surface litter. The perennial bushes remain green throughout the year, although portions may die back or shed leaves in excessively dry and hot summers to conserve moisture (Knowles & Condon 1951). Perennial grasses such as *Danthonia caespitosa* also produce a flush of growth with winter rains. They are better equipped to take advantage of unseasonal rainfall events than annual grass and herb species because they can regenerate vegetatively as well as from seed. They will however, dry off during the average hot summer (Dalton 1988). Competition may give annual species a seasonal advantage over perennial ones. After winter rainfall, fast-growing annual species rapidly exploit the readily available surface moisture, while during summer perennial species have the advantage of being able to tap deeper water supplies in the soil (Noy-Meir 1974).

Modifications to the natural vegetation due to land use

Rapid change to the natural vegetation of the Hay Plain came about with the introduction of sheep grazing and other farming practices. The spread of rabbits has also had highly destructive effects on the landscape.

Pre-European vegetation

The composition of the original saltbush vegetation on the Hay Plain prior to European impact has been debated. Some authors believe *Atriplex vesicaria* was the dominant species, others *Atriplex nummularia*. Most of the evidence suggests that *Atriplex vesicaria* was the more common and it is regarded in this and other publications as the original climax community (Beadle 1948, Knowles & Condon 1951). Beadle (1948) indicates that *Atriplex nummularia* was more abundant south of the Murrumbidgee River and in the eastern sector of the Plain. *Atriplex nummularia* shrublands are presently restricted to small remnant patches across the riverine plain while *Atriplex vesicaria* is much more widespread and abundant.

Moore (1953) presents evidence to show that the grasslands in the Narrandera, Urana and Jerilderie areas (in the south-east of the riverine plain) are disclimax or degraded communities once occupied by *Acacia pendula* and *Atriplex nummularia*. The original vegetation was an open woodland comprising trees of up to 10 m high with a well-developed shrub stratum which varied towards an *Atriplex nummularia* shrubland where the *Acacia* became infrequent. Associated shrubs included *Rhagodia spinescens*, *Enchylaena tomentosa*, *Maireana aphylla* and the poorly developed herb layer consisted mainly of *Danthonia* species, *Stipa falcata*, *Atriplex semibaccata*, *Maireana excavata* and various asteraceous herbs (Moore 1953). Similarly, much of the *Danthonia* grassland mapped in the current survey and by Beadle in 1948 has resulted from the clearing and grazing of the original communities.

Interestingly 'Coree', a property east of the current study, contains a significant area of *Atriplex vesicaria*, possibly occurring here at its south-eastern limit in Australia (Moore 1953). *Atriplex vesicaria* may have been much more common in these areas but was also grazed out. Moore (1953) also states that the original woodlands in the south-eastern riverine plain were open communities with a well-developed herbaeous stratum dominated by *Themeda australis*.

Grazing disturbance

The modification to the natural vegetation by sheep and cattle grazing on the Hay Plain has been immense. As the dominant land use, sheep grazing is concentrated on the rangelands, while cropping prevails closer to rivers and other water sources for irrigation. Not a single paddock appears to have escaped stock disturbance of one sort or another. The least disturbed areas of native vegetation exist in exclosures, home paddocks and reserves where stock have been excluded. A 43 ha exclosure seen in 1990 on 'Waterloo' south-east of Hay, has remained ungrazed for approximately 25 years and displayed great native species diversity and density of vegetation. Some of these sites however, especially those with loamy to sandy texture-contrast soils, may show significant degradation caused by rabbits and other feral animals.

The effects of grazing on native vegetation can range from complete clearing of perennials and their replacement by other species, to minor defoliation of perennial shrubs, trees and grasses. Grazing of seedlings also directly prevents regeneration in many communities. Some communities are partially modified by the thinning of the perennial vegetation when browsed by stock, which allows opportunistic species to become established. This is often seen in paddocks that are rotationally but intensively grazed in the short term. Species especially palatable to stock may be completely denuded and destroyed if stock rates are high and grazing pressure intensive. *Atriplex vesicaria*, *Atriplex nummularia*, *Maireana pyramidata* and *Maireana aphylla* are removed by inappropriate grazing, particularly with continuous heavy grazing (Beadle 1948, Leigh & Mulham 1965). These species may be replaced by opportunistic or exotic plants such as *Sclerolaena* species, thistles and introduced grasses. Some shrubland areas have been so heavily grazed that the original species have been entirely replaced by dense shrublands of *Nitraria billardierei*, *Sclerolaena muricata* and *Sclerolaena tricuspid* or by a suite of exotic annual grasses. Within most vegetation communities, particularly those with a more open structure, introduced annual and short-lived perennial grasses constitute the ground cover between scattered trees and shrubs. Invasion by other pasture species such as *Medicago* spp. and by various asteraceous herbs is also common. The ecological degradation of original plant communities to areas containing entirely disturbance-indicator species or annuals is a common result of grazing and clearing pressure on the Hay Plain.

It appears that sheep are highly selective even under conditions of low pasture availability (Leigh & Mulham 1966a, 1966b & 1967, Robards *et al.* 1967). In grazing trials the diet composition rarely conformed with that of the perennial pasture, a large proportion consisting of annual species such as **Hordeum leporinum* and **Medicago polymorpha*. Only in the summer when these are not available, were the dominant perennials grazed, as well as dry material such as medic burrs. In summer when very little other material was available, *Atriplex vesicaria* made up 90 per cent of the diet (Leigh & Mulham 1967). Within a *Maireana aphylla* shrubland, this species and medic burrs were favoured in summer. In winter there is a greater proportion of annual forage produced in the *Maireana aphylla* shrubland than in the *Atriplex vesicaria* shrubland (Leigh & Mulham 1966b). Grazing by native mammals appears to have a less damaging affect on chenopod shrublands. In areas where kangaroos congregate in large numbers they can remove all herbage in a similar manner to sheep. In contrast, however, they usually have little apparent effect on chenopod shrublands or tree seedlings (Wilson *et al.* 1984). Surveys have shown that kangaroos consume more grass than sheep (Wilson & Harrington 1984) and that red kangaroo populations are higher in mulga and box woodlands and *Danthonia* grasslands than in saltbush areas (Dalton 1988). Local variations in numbers are controlled by available herbage and shelter and population explosions during times of drought may have a negative effect on the already stressed vegetation.

While not observed during the present survey, some authors suggest that infrequent or short intensive periods of grazing actually increase shrub vigour and density. Osborn *et al.* (1932) and Knowles and Condon (1951) suggest that grazing by stock may have a pruning effect on *Atriplex vesicaria* promoting vigorous growth and compact bushes. If grazing was too heavy, however, shrubs started to deteriorate to the point of complete destruction under extreme conditions. Heavy intermittent grazing has been reported to improve the vigour of *Atriplex vesicaria* as well as seedling establishment (Ratcliffe 1936, Leigh & Mulham 1966a). It has also been suggested that this species may exhibit adverse symptoms in the absence of grazing, such as producing a large, scrappy form (Clift *et al.* 1987). Clift (1989) suggested that ungrazed or lightly grazed stands were often the first to experience dieback and were subsequently the slowest to regenerate. Other authors conclude that light grazing is more harmful to the vigour of *Atriplex vesicaria* communities than heavy or no grazing (Osborn *et al.* 1932). Similarly, infrequent or short intensive periods of grazing may actually increase plant species diversity within a community, a phenomenon occasionally observed along stockroutes within *Atriplex vesicaria* shrubland. These modifications to the vegetation are seen from the pastoral viewpoint of maximising grazing productivity. In terms of habitat sustainability such results may be degradational.

Modification of the original understorey due to grazing pressure is also common. An example of this is the *Acacia pendula* and *Atriplex nummularia* alliance described by Beadle (1948) and Moore (1953) which no longer exists today. The disappearance of the community is attributed to sheep grazing, bushfires, the severe drought of 1875-1877, the felling of *Acacia pendula* for stock feed and the use of the timber for firewood (Moore 1953). *Atriplex nummularia* is eaten readily by stock (Cunningham *et al.* 1981) and has been completely cleared as the understorey component of *Acacia pendula* woodland communities, to be replaced by perennial native and annual exotic grasses. Other vegetation communities have had their understoreys severely or completely cleared by direct grazing or trampling. Many *Eucalyptus largiflorens* and most *Callitris* woodlands have lost their original shrubby understoreys to grazing, with a replacement ground cover of annual and short-lived perennial grasses and herbs.

The shrubland and grassland communities on the Hay Plain may be regarded as various stages in a succession after grazing disturbance. A climax vegetation commu-

nity is one which is in equilibrium with its environment and is essentially a stable community over a relatively long period (Moore 1953). A community in disclimax phase has undergone changes of varying degrees as a direct result of land use practices such as grazing, clearing and burning. The grassland communities of the Hay Plain are considered to be disclimax communities with various degrees of degeneration in evidence (Moore 1953, Wilson & Graetz 1979). In any part of south-western New South Wales, *Danthonia* and *Stipa* species are not found as dominants except under grazing while *Chloris* species dominate only in areas subject to heavy or severe grazing (Moore 1953).

The successional process can also be seen in scald reclamation patterns where over the years the scalds become revegetated with the surrounding dominant matrix of vegetation via a number of intermediary communities. In the short term, the larger scalds appear to be colonised by species that are disturbance indicators such as *Nitraria billardiarei* and *Sclerolaena* species, *Maireana aphylla*, annual and short-lived perennial grasses such as **Hordeum leporinum* and **Lolium perenne* and annual herbage, particularly medic and other pasture species. The course of degeneration from healthy, dense Bladder Saltbush shrubland to bare scalded areas under grazing pressure can be followed. *Atriplex vesicaria* is initially replaced with *Maireana aphylla*, followed by *Sclerolaena* species and annual saltbushes, annual herbs and grasses and finally *Nitraria billardiarei*. Scalding occurs after extreme grazing has eliminated even the relatively unpalatable *Nitraria billardiarei* (Dalton 1988, Beadle 1948). Various states of ecological degradation can be monitored via these species.

Regeneration of many species is directly prevented by sheep grazing. Many shrubby understorey species are removed and any regeneration is prevented by persistent grazing. Trees of *Callitris glaucophylla* are not regenerating due to grazing pressure and older stands will ultimately die out. Regeneration of this species is rarely observed in the presence of stock and rabbits (Semple 1987b) while grazing herbivores also severely limit regeneration of *Casuarina pauper* and *Alectryon oleifolius* (Chesterfield & Parsons 1985). Protection from grazing promotes regeneration of key community species as well as the shrubby understorey.

Trampling by stock may also have a deleterious effect on vegetation leading ultimately to erosion. This occurs mostly in places of concentrated stock gathering such as watering points. Osborn *et al.* (1932) suggest that occasional trampling has the effect of planting seed, resulting in the overcrowding of bushes in an *Atriplex vesicaria* shrubland.

Saltbush and bluebush shrublands are considered to be of low resilience due to their susceptibility to overgrazing and the instability of the soils with vegetation removal (Graetz & Wilson 1984). Despite some recovery of *Atriplex vesicaria* after the dieback event of 1977–1983, many areas on the Hay Plain have still not recovered. Twenty-eight per cent of the country which previously carried healthy saltbush is still in a degraded state, particularly those areas south of Hay and between the Lachlan and Murrumbidgee Rivers (Clift *et al.* 1989, Semple 1989). Grazing pressure and mismanagement of regenerating stands appears to be the cause.

Clearing and cropping

Clearing for agriculture has the most extreme effect on the natural vegetation in that it is removed completely and regeneration is prevented. Irrigated crop growing is a major farming industry on the arable lands adjacent to major rivers and creeks. Within the mapped area, the floodplain country of the Murray River has been extensively cleared and cropped, primarily for rice, fruit and wheat. Few intact areas of native vegetation remain, most existing as remnant trees within cropped paddocks. The less

extensive floodplains of the Murrumbidgee and Lachlan Rivers further north have been irrigated and cropped to a lesser extent. Some cropping is carried out in the dry lake basins north-west of Booligal and south of Ivanhoe, mostly after infrequent flooding events.

Logging

Many areas of the Hay Plain that were once wooded or forested have been cleared or thinned. *Callitris glaucophylla* was used for building and fencing and has been cleared considerably. *Acacia pendula* has been similarly cleared in the east of the Plain. River Red Gum timber is also highly valued, for heavy building work, railway sleepers, fencing and furniture making; logging of this species is the major activity in the State Forests on the Murray and Murrumbidgee Rivers. Charcoal production using River Red Gum logs and offcuts is an old industry maintained today at Mathoura. The original composition of these communities is also modified by logging, and many woodland and open forest areas are consequently prone to weed invasion. Timber-cutting in the Barmah-Millewa forests on the Murray River has altered their structure, from predominantly large old trees with patches of younger trees to young trees with few of the original forest giants (Somerville 1988).

Salinity

The removal, recycling and regulation of ground water is disrupted with the removal of vegetation. Without plant cover to regulate it, the water table rises, bringing dissolved salts to the soil surface and resulting in soil salinity. Surface salinity is a particular problem in areas of heavy irrigation and other situations where there is a high influx of water and little vegetation cover. Existing vegetation can also die off with increasing soil salinity, to be replaced by more salt-tolerant species. In extreme cases the result is a saltpan on which few plants can grow. Salinisation is a problem in some irrigated areas along the Murray River and appears to be more severe in the intensively irrigated areas across the river in Victoria. However in the Tullakool Irrigation Area near Wakool, rising salinity has necessitated the installation of a subsurface drainage system and evaporation ponds.

Erosion

Soil erosion is exacerbated with the removal of vegetation. Scalding, the removal of the top soil horizon by wind action, is commonly seen on the Hay Plain. Duplex and deeper sandy soils are particularly scald-prone, as the sandy to loamy surface soil is removed, exposing the heavier clay B-horizon. Abraham (1987) notes that the red-brown earths occurring in the eastern Hay Plain are texture-contrast soils with hard-setting loamy topsoils which are not as susceptible to scalding as the sandier topsoils occurring as sandsheets further west. Source-bordering dunes, lunettes and low sandy rises are also susceptible to windsheeting (the removal of thin surface layers of soil by wind) and drift (the removal and accumulation of sand either on the eroded surface or against adjacent obstructions) (Dalton 1988, Condon & Stannard 1957).

The regeneration of scalded areas is limited by high exposure of the surface soil to temperature, evaporation and wind movement, and by the low water infiltration rates and limited seed source in the soil (Beadle 1948b). Abraham (1987) believes that the rate of scald revegetation is slowing down, and that many remaining scalds are unlikely to revegetate naturally as their sloping surfaces do not hold water as efficiently as the already reclaimed flat surfaces. *Atriplex vesicaria* is reported to be the most successful native shrub for sowing onto scalded and degraded land, followed by *Atriplex nummularia* to a lesser extent (Muirhead & Jones 1966, Alchin 1974). Germination rates are low and seeding rates therefore need to be high.

Erosion is exacerbated by the presence of rabbits which disturb the soil, often on a massive scale. Huge warrens were observed in many sandy sites on the Plain, often exposing the root systems of existing trees. Sheep and cattle remove existing vegetation by grazing and cause soil erosion by trampling. Gully erosion due to water runoff is not common on the Hay Plain but was observed in several heavily irrigated sites in the south.

Feral herbivores

Of all the animals introduced to inland Australia rabbits have had the greatest impact on the environment. Grazing by rabbits, particularly of seedlings, contributes to the overall land degradation by preventing regeneration of community dominants. *Callitris* woodlands on prior stream ridges and low dunes and the Belah-Rosewood sandplains have been most affected by rabbit invasion. Away from the sandier habitats, *Atriplex nummularia* and *Nitraria billardierei* shrublands on the alluvial plains provide excellent shelter for rabbits (Dalton 1988). The eastern area of the Hay Plain, bounded by Booroorban, Four Corners and Carrathool has been described by local sources as the most rabbit-infested area of the Plain (Dalton 1988).

Pigs, goats and foxes continue to be a problem in western New South Wales. Feral pigs are common in the swamp and floodplain areas of the Lachlan-Murrumbidgee confluence but are not so prevalent on the saltbush plains (Dalton 1988). Goats are a serious problem in rocky habitats and groups were observed on Warranary Hill within the study area, where the vegetation is noticeably cropped and there is some soil erosion.

Introduced plants

A major modification to the natural vegetation has been the introduction and establishment of exotic species and non-local native taxa. Many of these plants, particularly the introduced pastoral species and weeds, have become a prominent part of the landscape, usually dominating the winter pasture and ground layer within many vegetation communities. Introduced pasture species such as **Hordeum leporinum*, **Lolium perenne*, **Avena fatua*, **Medicago* and *Erodium* species have become so established as to dominate the herbaceous layer of most communities on the Plain. In the current survey, 21 per cent of the species recorded are introduced taxa (Appendix 1). Semple (1987a) found that a third of the species present within an ungrazed prior stream site were naturalised. The high proportion of naturalised taxa has serious implications for natural vegetation management on the Hay Plain.

Common woody species that have become naturalised include **Lycium ferocissimum* and **Nicotiana glauca*. Common herbs and forbs that have become pests in many areas of the Plain include **Xanthium spinosum*, **Echium plantagineum*, **Cirsium vulgare*, **Sonchus oleraceus*, **Arctotheca calendula*, **Heliotropium europaeum*, **Brassica rapa* and **Sisymbrium* species. Weed species may cause particular problems with revegetation projects and rehabilitation of natural vegetation. Vigilant weeding programs need to be carried out in such cases, where weeds impede desired plant growth. These species, carried in by rivers or introduced with domestic stock or cropping, continue to be dispersed by animals, winds and vehicles (Beadle 1981).

Nitraria billardierei, a native species, has successfully colonised many cleared and disturbed areas on the Hay Plain. Native woody shrubs such as *Dodonaea viscosa* subsp. *angustissima* and *Senna* species often colonise disturbed areas on sandy soils in dense monospecific thickets and are considered weeds by graziers as they reduce the grazing potential of the land. *Callitris glaucophylla*, relatively rare on the Hay Plain, is regarded as a woody weed in some parts of the western slopes and the Pilliga region because of its dense regrowth in these areas. Historical records indicate that natural

fluctuations occur in the densities of native woody species. Denney (1992) suggests that the woody weed outbreaks are a successional stage that, if left alone, will slowly change towards the original woodland-grassland vegetation.

Natural modifications

Dieback events

The most recent and devastating modification to the vegetation on the Hay Plain has been the widespread dieback of *Atriplex vesicaria*. Between 1977 and 1983 dieback resulted in a decrease in the area of *Atriplex vesicaria* shrubland on the Plain by 53 per cent (Clift *et al.* 1987). It has since been replaced by shrublands of *Sclerolaena muricata*, *Sclerolaena tricuspis*, *Maireana aphylla* and annual or short-lived perennial grasses. Localised dieback of *Maireana pyramidata*, *Maireana sedifolia*, *Maireana aphylla* and *Atriplex nummularia* also occurred in some areas. At the time, many believed the future presence of *Atriplex vesicaria* on the Plain was in doubt, such was the severity of the dieback. The saltbush recovered somewhat with general regeneration from seedlings and reshooting after early summer rains in 1984, but did not completely regenerate in all areas, especially south of Hay (Clift *et al.* 1989, Semple 1989).

Dieback is believed to be a product of exceptional rainfall (Semple 1989). Shrubs send out shallow, short-lived feeding roots which prove inadequate during ensuing dry spells for plant survival. A lack of effective summer rain coupled with the above-average winter rain may promote strong competition from annual grasses and forbs which deplete the surface soil moisture. Other effects of above-average rainfall may be the disruption of normal *Atriplex vesicaria* growth, the strong competition between shrubs as well as from annuals and the proliferation of wilt-inducing pathogens. Caterpillars and weevil larvae (borers) are thought to contribute to saltbush death by defoliating the shrubs (Semple 1989). They are more likely to be secondary invaders as the low numbers seen were not consistent with defoliation and it seems that the caterpillar plagues coincided with, rather than initiated the dieback. Subsequent maintenance of the pre-existing grazing pressure in these areas is also detrimental to saltbush regeneration.

Fire

Aboriginal people regularly burned the grassland of the plains to promote the growth of young grasses and seeds, both to collect and to attract game (Mullins *et al.* 1982). The incidence of naturally occurring wildfires in the area is unknown although lightning strikes could certainly cause ignitions in woodland areas of the Plain. *Atriplex vesicaria* and *Atriplex nummularia* are naturally resistant to fire (Leigh & Mulham 1965), although they may be destroyed if sufficient fuel has built up between the shrubs in the form of dried grasses and litter. The regeneration of these species after fire is slow, especially if the seed source has also been destroyed (Hodgkinson 1983, Hodgkinson *et al.* 1984). *Maireana aphylla* and *Maireana pyramidata* are not as adversely affected by fire although their densities may be reduced after wildfire (Leigh & Noble 1981).

Grassland areas south-east of Hay were affected by fire in November 1990 which was ignited from the Sturt Highway. Widespread fires in 1991 also burned a huge area north-east of Booligal to Willandra Creek. Few shrublands remain in the eastern half of the map due to the combined effects of clearing, grazing and fires. Trees appear to have survived these fire events better and coppice growth was observed north-east of Booligal. The mallee in the north-east of the mapped area has a history of regular burning. Fires occurred in the Roto-Hillston region in 1940 and 1956 to 1957 (Denney 1992) and parts of the mallee country in the Cobar Shire, situated north of Roto, were

burnt during the wildfires of 1974–75 (Noble *et al.* 1980). Much of the mallee here is of the 'whipstick' form, which is highly combustible. *Triodia*, commonly associated with whipstick mallee on the dune-crests, is also extremely flammable due to its high litter accumulation (Noble *et al.* 1980).

Drought

Drought is normally declared when at least 50 per cent of properties over a widespread area contain insufficient water or feed to sustain stock (Dalton 1988). The famous droughts of 1883–1885 and 1890–1894 resulted in substantial degeneration of saltbush and grassland pastures. Drought conditions bring additional grazing pressure and place stress on the natural vegetation. The felling of trees and lopping of foliage from various species such as *Casuarina pauper*, *Alectryon oleifolius*, *Geijera parviflora* and *Acacia pendula* for stock feed is a common practice during drought (Grant 1989).

Atriplex vesicaria has a high drought resistance, having the ability to absorb moisture through the leaves from rainfall and dew, due to the high concentrations of soluble salts in the leaves (Knowles & Condon 1951). Very fine hairs on the leaves assist in water absorption and collapse during dry periods to form a protective, water-retaining covering. The plant can also rapidly produce feeding roots following good rains and, if severe drought conditions prevail, it sheds leaves. Seemingly dead, defoliated bushes, often reduced to black sticks, may be in a condition that minimises water loss (Knowles & Condon 1951).

Flooding and high rainfall

Flooding events are essential for the survival of several major species on the Plain. *Eucalyptus camaldulensis* requires regular inundation for seed dispersal and establishment as does *Eucalyptus largiflorens* to a lesser extent. *Lignum* (*Muehlenbeckia florulenta*) grows rapidly during wet periods while *Chenopodium nitrariaceum* and *Eragrostis australasica* are also adapted to periods of inundation (Cunningham *et al.* 1981). Flooding influences the distribution of such communities by facilitating seed dispersal and initial establishment. The natural hydrology of the major rivers has been changed with river regulation practices and floods are not as common now as they would be naturally (Dalton 1988). The removal of vegetation cover and subsequent increase in erosion has increased the sediment loads in many rivers (Schumm 1968).

It has been suggested that the abnormally high rainfall years of 1973 and 1974 indirectly contributed to the widespread dieback of *Atriplex vesicaria* from 1977 to 1983 (see 'Dieback events' in this section). *Atriplex nummularia* is well-adapted to low-lying areas that receive extra run-on and can withstand long periods of inundation, even germinating in waterlogged soil. Plants of *Atriplex vesicaria* are not as flood-tolerant although the seeds are not affected and are the main means of regeneration after a flood (Dalton 1988).

Conservation of vegetation

The vegetation of western New South Wales is very poorly conserved, considering that many plant communities are threatened due to continuing land use practices (Benson 1989, 1991). Only about two per cent of the Western Plains is conserved in national parks or nature reserves (Benson 1988). The flora in agricultural zones is the most poorly conserved. Vegetation groups which have the poorest conservation status in New South Wales include inland *Acacia* shrublands and *Casuarina* woodlands, chenopod shrublands of the southern plains, box woodlands and communities of inland watercourses and floodplains (Benson 1989, 1991). The Hay Plain comprises a

significant area of chenopod shrublands, semi-arid woodlands and riverine forest, constituting the heart of the Murray–Darling catchment area. Few of the vegetation communities representative of the Hay Plain are protected in reserves.

Willandra National Park (19 386 ha) and Goonawarra Nature Reserve (437 ha) are the only formal reserves within the mapped area (excluding Sandune Pine Flora Reserve, a relatively small reserve managed by the Forestry Commission, on the Murray River) representing a conserved proportion of only 0.45 per cent. The variety of vegetation communities within these reserves is limited and they do not adequately represent the botanical biodiversity of the Hay Plain. Willandra National Park was to have realised the conservation of riverine plain *Atriplex vesicaria*, but after 20 years of grazing protection it comprises mostly modified *Maireana aphylla* shrubland and open grassland. In the intensively irrigated areas south of Deniliquin, few areas remain in which the original vegetation still survives. There is an urgent need to protect key sites for preservation.

Significant vegetation communities

The most vulnerable communities on the Hay Plain presently are those growing on the sandy duplex soils of low rises, prior streams and sandplains. These soils are highly erosion-prone due to the combined effects of vegetation removal by overgrazing and undermining by rabbits. In a priority-order of vegetation communities for conservation in the southern Riverina, Brickhill (1985) lists *Callitris*-dominated and *Acacia pendula* communities as top-priority. Table 4 indicates the threats to and present conservation status of vegetation communities occurring on the Hay Plain.

Callitris glaucophylla Mixed Woodland (Community 16) and Prior Stream Remnant Woodland (Community 27) are vulnerable communities of particular concern. They suffer from removal of understorey species and the prevention of seedling establishment due to grazing and trampling by stock, undermining by rabbits and erosion due to vegetation loss. Notable sites include 'Steam Plains' and 'Zara' north of Deniliquin (Brickhill 1985), 'Oolambeyan' south-east of Hay, and the Boorooban, Tholobin, Puckawidgee and Edgar State Forests. The 'Steam Plains' and 'Zara' areas also contain unusual and rare understoreys of *Atriplex nummularia*. As well as being logged, the State Forest areas are often leased out to landholders and suffer intensive grazing pressure with little or no regeneration of tree species. The Tholobin State Forest is particularly degraded, with rabbit infestation, heavy logging and overgrazing. Immediate acquisition some of these sites will prevent the loss of these remnant old woodlands in future years. Fencing off some of these areas from stock and rabbits would allow natural regeneration of the pine and re-establishment of the shrubby understorey. The 'Zara' sandhills, which have been fenced-off in the past and are in a relatively natural condition, and sites within the Steam Plains, Puckawidgee and Edgar State Forests could be targeted for regeneration. The relative rarity of *Callitris* Mixed Woodland on the Hay Plain today and the degraded state of prior streams give these communities particular conservation significance.

The higher, red-earth floodplain country between Deniliquin and the Murray River also remains unconserved. This area contains remnants of *Eucalyptus microcarpa* woodland with *Allocasuarina luehmannii* and *Eucalyptus melliodora* (Community 24) and areas of *Callitris glaucophylla* woodland (Community 16). It has been almost entirely cleared for irrigation with cropping up to and below the trees. Small roadside remnants remain, some with well-developed shrubby understoreys of local *Acacia* and *Senna* species and their acquisition for formal reservation is particularly urgent. Areas of *Eucalyptus microcarpa*, *Eucalyptus melliodora* and *Callitris glaucophylla* are listed as high priority communities for conservation, with proposed sites at Wahgunyah and

Table 4. Present conservation status of and threats to vegetation communities occurring within the Booligal, Hay and Deniliquin-Bendigo 1:250 000 map areas (adapted from Brickhill 1985, Benson 1989 and Morgan & Terrey 1992).

Community	Threats	Effects	Conservation Status
1 Riverine Forest	forestry activities, river regulation, irrigation, clearing for cropping, grazing, recreational activities	minor reduction in range and populations, younger age class over much of its distribution	Inadequately conserved, vulnerable; some conserved in Goonawarra Nature Reserve (437 ha) along the Lachlan River but conservation status extremely poor along Murray and Murrumbidgee Rivers, the former containing the largest stands in Australia.
2 Black Box Woodland	grazing and cropping	major reduction in range and populations, major alteration of understorey, older age class over much of its distribution	Inadequately conserved but not threatened in the foreseeable future; some conserved in Goonawarra Nature Reserve and Willandra National Park.
3 Mallee	grazing, cropping, significant changes in fire regime, rabbit invasion	major reduction in range and populations, major alteration of understorey	Adequately conserved in Nombinnie, Round Hill and Yathong Nature Reserves, and Mallee Cliffs National Park, outside the mapped area and not threatened in the foreseeable future.
4 Belah-Rosewood	grazing, rabbit invasion, cropping	major reduction in range and populations, major alteration of understorey, little regeneration, older age class over much of its distribution	Inadequately conserved, vulnerable; very widespread and not conserved over its range.
8 Black Bluebush	grazing, rabbit invasion	minor reduction in range and populations	Poorly conserved but not threatened in the foreseeable future. Pearl Bluebush poorly conserved and vulnerable.
11 Bladder Saltbush	grazing, cropping, dieback events	major reduction in range and populations	Poorly and inadequately conserved, vulnerable; none conserved on the Hay Plain

Table 4 (continued)

Community	Threats	Effects	Conservation Status
12 <i>Sclerostegia tenuis</i>	grazing, cropping, dieback events	major reduction in range and populations	Not conserved, vulnerable.
13 Canegrass	grazing, irrigation dryland cropping	minor reduction in range and populations	Inadequately conserved, vulnerable.
16 <i>Callitris</i> Mixed Woodland	grazing, rabbit invasion, cropping, some logging	major reduction in range and populations, major clearing and alteration of understorey, little regeneration, older age class over much of its distribution, soil erosion	Inadequately conserved, vulnerable; some areas endangered on the Hay Plain under current threats.
17 <i>Acacia melvillei</i> Woodland	grazing, rabbit invasion, cropping, some cutting for domestic firewood	minor reduction in range and populations	Not conserved over its range, vulnerable.
18 Lignum and <i>Chenopodium nitriaceum</i>	irrigation and drainage, clearing for cropping and grazing	major reduction in range and populations	Inadequately conserved, vulnerable; some conserved within Goonawarra Nature reserve. Currently being cleared along the Murrumbidgee River for irrigation.
19 Old Man Saltbush	grazing	major reduction in range and populations	Not conserved, endangered; extinct in some regions and relatively rare on the Hay Plain.
21 Cotton Bush	grazing	overall increase in range and populations on the Hay Plain with Bladder Saltbush dieback	Vulnerable to overgrazing; conserved within Willandra National Park (19 386 ha), most of which comprises this shrubland.

Community	Threats	Effects	Conservation Status
23 Great Cumbung Swamp	irrigation and drainage, resulting from river regulation, grazing	minor reduction in range and populations	Inadequately conserved but not threatened in the foreseeable future.
24 Grey Box Woodland	grazing and clearing for cropping	major reduction in range and populations, major clearing of understorey, little to no regeneration, older age class over much of its distribution	Not conserved, vulnerable to endangered; intact communities, especially with Yellow Box, rare on the Hay Plain. Some <i>Allocasuarina lehmannii</i> conserved off the mapped area but inadequately so.
25 <i>Acacia pendula</i> Woodland	grazing, cropping and some lopping for fodder	major reduction in range and populations, major alteration and clearing of understorey	Not conserved, endangered by clearing; intact Old Man Saltbush understorey extremely rare.
26 White-top Grassland	grazing and cropping	major reduction in range and populations	Not conserved but not threatened in the foreseeable future.
27 Prior Stream Remnant Woodland	grazing, rabbit invasion, cropping	major reduction in range and populations, major alteration of understorey, little regeneration, soil erosion	Not conserved, vulnerable; some areas endangered on the Hay Plain under current threats.
28 <i>Casuarina pauper</i> / <i>Casuarina cristata</i> Intergrading Population	grazing, cropping, some rabbit invasion	minor reduction in range and populations, major alteration of understorey	Not conserved, vulnerable; possibly cleared for cropping east of the mapped area.
29 Rocky Outcrop Woodland Complex	grazing, clearing, feral animals, significant changes in fire regime	minor reduction in range and populations, major alteration of understorey	Not conserved but not threatened in the foreseeable future.

Bucklingbong State Forests, to the east of the mapped area (Brickhill 1985). Also unreserved are the small isolated sandhills of the Murray floodplain supporting *Callitris gracilis* subsp. *murrayensis* (Murray Cypress Pine). Small, unmapped and rare remnants of shrubs such as *Melaleuca lanceolata* and *Acacia rigens* occur around Deniliquin. Any small vegetation remnants in areas of intensive land use must be assumed to have a high conservation value (Morgan & Terrey 1992).

The conservation status of *Atriplex vesicaria* (Community 11) and other chenopod shrublands on the Hay Plain is considered extremely poor (Benson 1988). Large areas have been reduced to ephemeral grasslands with *Sclerolaena* species, or to *Maireana aphylla* shrublands, particularly around the Lachlan River in the north-east of the mapped area and south of Hay. The majority of the 19 386 ha of Willandra National Park is not considered representative of the vegetation on the Plain since no *Atriplex vesicaria* has been recorded there and has not returned after 20 years of grazing protection. The Park was established within highly disturbed and modified vegetation which was expected to return to a species mix close to that which existed before grazing (Lunnon 1988). The properties presently surrounding the Park contain mostly open annual grasses and herbfields where grazing pressure continues to be high. The present survey has indicated that the best areas of *Atriplex vesicaria* remain in little-disturbed sites such as exclosures and on areas only periodically and lightly grazed, such as certain stockroutes. The most extensive tracts occur north to north-west of Hay and west of Booligal; however these have declined considerably both in area and condition over the past 15 years, as a consequence of dieback events. Beadle (1948) mapped *Atriplex vesicaria* as far south as the Edward River with patchy areas further south. Small stands remaining between Moulamein and Wanganella represent the southern limit of its distribution on the Hay Plain. Any native shrublands south of this limit have been completely cleared, making the preservation of the southern-most remnants all the more significant. Further investigation into the causes of dieback is essential for the future survival and management of this community. The procurement of a more representative reserve, entirely protected from grazing and within the existing area of *Atriplex vesicaria* is needed to ensure the preservation of this important shrubland.

Remnant areas of *Atriplex nummularia* shrubland (Community 19) occur throughout the Hay Plain but its distribution is very patchy. Once much more extensive, it has been reduced to small relict areas, often around homesteads and in small holding paddocks. The shrub is also found as an understorey to Black Box, at sites between Moulamein and Wanganella and north-east of Hay, and on 'Steam Plains' with *Callitris glaucophylla*. The 'Steam Plains' site has been listed as the best remaining stand of this community and nominated as a proposed conservation reserve (Brickhill 1985). As a relatively rare type of native shrubland on the Hay Plain today, the protection of these remnants is highly desirable.

Acacia pendula is also inadequately represented in the conserved estate. Regeneration in the field is sporadic and young plants are often damaged by grazing, since the foliage is palatable to stock (Beadle 1981). Intact woodlands now only occur as isolated remnants, having been largely altered to short-lived perennial or annual grasslands. *Acacia pendula* requires detailed survey as a matter of priority to determine the options available for conserving representative areas (Morgan & Terrey 1992). A survey of *Acacia pendula* and *Acacia homalophylla* distribution in western New South Wales is currently underway (M. Fox in prep.).

The long-term future of tree species in the lower rainfall zone of the Hay Plain is also of great concern. Belah-Rosewood (Community 4) is very poorly protected throughout its range (Benson 1988) and remains unprotected within the mapped area. Graz-

ing seriously limits the regeneration of *Casuarina pauper* and *Alectryon oleifolius* to the extent that the future of these species on pastoral land is regarded as severely threatened in the long-term (Chesterfield & Parsons 1985). *Alectryon oleifolius* in particular is highly palatable to grazing stock, rabbits and goats, and regenerates by suckers; seedlings are rarely found. *Casuarina pauper* regenerates by limited seedling production and suckering appears insufficient to perpetuate stands of the species (Chesterfield & Parsons 1985). A reduction in grazing pressure will also be necessary to protect the erosion-prone soils.

The conservation status of riparian and floodplain ecosystems of the Murray, Murrumbidgee and Lachlan River systems is extremely poor. There appears to be an urgent need to establish a reserve in the *Eucalyptus camaldulensis* forests of the Murray River which, except for Kemendoc Nature Reserve west of the mapped area, remain virtually unconserved in New South Wales. The largest stands of this species in Australia occur in the southern Riverina (Brickhill 1985). *Eucalyptus camaldulensis* is considered well conserved in Victoria in such reserves as Hattah-Kulkyne National Park (Murray-Darling Basin Ministerial Council 1987). Many of the most significant stands of the species in New South Wales are in State Forests and the continued logging is compromising the selection of representative conservation areas. At present no substantial River Red Gum forest is adequately conserved in New South Wales (Morgan & Terrey 1992). The forests of the Barmah-Millewah area form the only tall open forest on the western slopes and plains and remain unconserved. There is no doubt that the management of these forests for timber production very often has a detrimental effect on nature conservation (Somerville 1988). The flora reserves gazetted by the Forestry Commission are considered inadequate and the conservation of *Eucalyptus camaldulensis* in secure reserves free from all logging and grazing should be high on the conservation agenda (Somerville 1988).

The Black Box vegetation of the Murrumbidgee River is represented near Balranald in Yanga Nature Reserve but further representation in the east is desirable. The Murrumbidgee River is highly regulated within the mapped area and few suitable sites exist. Localities such as Darlington Point east of the mapped area could be targeted for conservation. Kinchega National Park south-east of Broken Hill reserves *Eucalyptus largiflorens* and some *Eucalyptus camaldulensis* on the Darling River (Benson 1988). One of the biggest threats to inland river systems is their contamination by chemicals and salts, and nutrient enrichment from fertilisers and livestock droppings that result in algal blooms. Changed flooding regimes due to river regulation have also affected regeneration of many River Red Gum and Black Box communities.

Other important unprotected vegetation occurs as ephemeral wetlands. Areas of *Muehlenbeckia florulenta* and *Eragrostis australasica* provide habitat for thousands of waterbirds when flooded (Pressey 1988). The Booligal wetland complex is associated with the Lachlan River downstream of Booligal and encompasses the Merrowie, Merrimajeel and Muggabah Creek anabranches. The channels and lake basins contain extensive stands of *Muehlenbeckia florulenta*, *Eucalyptus largiflorens* and *Eucalyptus camaldulensis*. Although containing these species, Goonawarra Nature Reserve is considered only marginal to, and not representative of, the Booligal wetlands (Pressey 1988). The Great Cumbung Swamp of the Lachlan-Murrumbidgee confluence is not protected at all by reserves. Inland reed swamps are commonly burnt to promote new green growth for stock while large areas of Lignum are presently being cleared for irrigation development on the lower Murrumbidgee within the mapped area (Pressey 1988). Other threats to wetland areas include the hydrological changes imposed by dams and weirs, sheep and cattle grazing (which commonly prevents the regeneration of Black Box and River Red Gum), logging, and lake-bed cropping which can cause salinity problems where irrigated (Pressey 1988).

Table 5. Species of particular conservation significance recorded for the Booligal-Hay and Deniliquin-Bendigo 1:250 000 map sheets. (A) Species nationally listed as rare or threatened (Briggs & Leigh 1988) and (B) species with restricted distributions in the Western Division of New South Wales (Pressey *et al.* 1990).

Risk Codes (Briggs & Leigh 1988)

2 Maximum geographic range of less than 100 km. **3** Range over 100 km but restricted to highly specific and localised habitats. **X** Species not recorded for at least 50 years and presumed extinct. **E** Endangered species at risk of disappearing within one or two decades under present land use. **V** Vulnerable species not presently endangered but at risk of disappearing over a longer period (20-50 years). **Ca** Adequately reserved with a total conserved population of 1000 plants or more. **CI** Inadequately reserved with a total conserved population of less than 1000 plants.

Category and Priority Codes (Pressey *et al.* 1990)

Category 1 Species occurring only in the Western Division with a restricted distribution. **Category 2** Species occurring only in New South Wales with a restricted distribution within and outside the Western Division. **Category 3** Species with a restricted distribution in the Western Division and also occurring interstate with **A** a small range and/or few records or **B** a wide range and/or many records. **Category 4** Species with disjoint occurrences in the Western Division with **A** the main population interstate and **B** the main population in New South Wales. **Priority 1** Protection measures in the Western Division will completely determine the survival of the taxon nationally. **Priority 3** Conservation of these taxa in the Western Division will influence their overall survival. **Priority 4** Protection in the Western Division is desirable to conserve the genetic variation within the ranges of these taxa.

(A) Taxa	Risk Code	Habitat
AMARANTHACEAE <i>Ptilotus extenuatus</i> Benl.	2X	Known from only two collections, one made in 1818 with no precise locality recorded and one from 'Zara' station north-west of Deniliquin in 1919. Despite numerous searches, it has not been collected for the past 73 years and is believed to have been grazed-out by domestic stock and rabbits (Briggs & Leigh 1988).
ASTERACEAE <i>Brachycome papillosa</i> G.L. Davis	3V	<i>Maireana aphylla</i> shrubland within Willandra National Park (present survey). Also recorded from <i>Atriplex vesicaria</i> communities on clay soils (Community 1) (Semple 1986, Leigh & Mulham 1977).
BRASSICACEAE <i>Lepidium monophlooides</i> F. Muell.	3ECi	<i>Maireana pyramidata</i> shrubland (Community 8, present survey). Also recorded by Leigh & Mulham (1977) and Margules & Partners <i>et al.</i> (1990).
CHENOPODIACEAE <i>Maireana cheelii</i> (R.H. Anderson) P.G. Wilson	3V	<i>Atriplex vesicaria</i> shrubland (Community 11) (Semple 1986, Leigh & Mulham 1977).

CYPERACEAE <i>Eleocharis obicis</i> L.A.S. Johnson and O.D. Evans	3V	Depressions with <i>Eragrostis australasica</i> (present survey, Community 13) but also recorded from <i>Atriplex vesicaria</i> (Community 11) and <i>Atriplex nummularia</i> (Community 19) shrublands (Cunningham & Milthorpe 1981)
ERIOCAULACEAE <i>Eriocaulon australasicum</i> (F. Muell.) Korn	2Vca	Recorded as a collection in 1853 from 'wet places along the Murray towards junction of Murrumbidgee' (Mulham & Jones 1981).
FABACEAE-FABOIDEAE <i>Swinsona murrayana</i> Wawra	3V	<i>Atriplex vesicaria</i> (Community 11), <i>Acacia pendula</i> (Community 25) and <i>Maireana aphylla</i> (Community 21) communities, the latter in Willandra National Park (present survey).
<i>Swinsona plagiotropis</i> F. Muell.	3ECi	Roadsides, rail reserves, stock routes and areas of lightly grazed unimproved pasture, in <i>Danthonia</i> spp./ <i>Enteropogon acicularis/Stipa</i> spp. grassland communities. Found on the plains country around Jerilderie and on the Murray Valley plains south of Echuca in Victoria. One site for the species is reserved in Wharparilla Flora Reserve near Echuca in Victoria, however the population presently comprises only two individuals (Appleby <i>et al.</i> 1991). Most of the <i>Swinsona plagiotropis</i> sites in the Jerilderie area also have populations of <i>Swinsona murrayana</i> . Although not recorded from the mapped area, this species is considered significant for the Hay Plain in its wider context.
(B) Taxa	Cat./Prior.	Habitat
AIZOACEAE <i>Zaleya galericulata</i> subsp. <i>australis</i> (Melville) Hj. Eichler	3B/4	Recorded from a <i>Maireana pyramidata</i> shrubland (Community 8) during the present survey.
ASTERACEAE <i>Brachycome exilis</i> Sond.	3B/4	A <i>Maireana pyramidata</i> community (Community 8) on a sand ridge (Leigh & Mulham 1977).
BRASSICACEAE <i>Cuphonotus humistratus</i> (F. Muell.) O.E. Schultz	2/3	<i>Atriplex vesicaria</i> and <i>Maireana aphylla</i> communities (Communities 11 and 21) (Semple 1986).
<i>Menkea australis</i> Lehm.	3B/4	Widespread in northern districts of the riverine plain where it may be locally common (Leigh & Mulham 1977).
<i>Pachymitrus cardaminoides</i> (F. Muell.) O.E. Schultz	3B/4	Recorded from 'Zara', north-west of Deniliquin in 1903 and probably overlooked since then (Mulham & Jones 1981).

Table 5 (continued)

B) Taxa	Cat./Prior.	Habitat
<i>Rorippa eustylis</i> (F. Muell.) L.A.S. Johnson	3B/4	A <i>Eucalyptus camaldulensis</i> community (Community 1) (Margules & Partners <i>et al.</i> 1990) and a swampy area on a river flat near Deniliquin (Mulham & Jones 1981).
<i>Stenopetalum velutinum</i> F. Muell.	3B/4	Recorded from Wanganella in 1903 (Leigh & Mulham 1977).
CHENOPODIACEAE <i>Dysphania littoralis</i> R.Br.	4A/4	<i>Eucalyptus camaldulensis</i> woodlands in moist low-lying areas (Community 1) (Mulham & Jones 1981).
<i>Sclerolaena limbata</i> (J.M. Black) Ulbr.	3B/4	<i>Atriplex vesicaria</i> shrubland (Community 1) (present survey).
FABACEAE-FABOIDEAE <i>Swainsona reticulata</i> J. Black	4B/4	Confined to clay and clay-loam soils in the southern and eastern districts of the riverine plain (Leigh & Mulham 1977).
<i>Swainsona sericea</i> (A. Lee) H. Eichler	4B/4	Confined to clay and clay-loam soils in the southern and eastern districts of the riverine plain (Leigh & Mulham 1977).
FABACEAE-MIMOSOIDEAE <i>Acacia pycnantha</i> Benth.	4B/4	Isolated occurrences in the Tocumwal-Berrigan area (Leigh & Mulham 1977), possibly just within the extreme south-eastern corner of the mapped area.
MYRTACEAE <i>Eucalyptus porosa</i> F. Muell. ex Miq.	3B/4	A single tree was recorded from <i>Eucalyptus largiflorens</i> woodland (Community 2) in an enclosure protected from grazing (present survey). Also recorded from the Moulamein district (Leigh & Mulham 1977).
POLYGONACEAE <i>Muehlenbeckia diclina</i> (F. Muell.) Druce	3B/4	Recorded from 'Manfred', south-west of Ivanhoe (Leigh & Mulham 1977) which is outside the mapped area but still on the riverine plain.
PORTULACACEAE <i>Calandrinia volubilis</i> Benth.	3A/3	<i>Atriplex vesicaria</i> communities (Community 1) (Leigh & Mulham 1977, Semple 1986).

The conservation status of some of the other communities mapped appears to be satisfactory. The central western mallee communities are well represented in a number of nature reserves to the north-east of the mapped area, including Yathong, Round Hill and Nombinnie Nature Reserves. The acquisition of Nombinnie along with Yathong Nature Reserve has consolidated the conservation of the *Eucalyptus socialis*-*E. dumosa*-*E. gracilis* association (Benson 1988). The southern mallee outlier, however, between Griffith and Hillston is almost completely cleared and cultivated. Clearing for grazing and cropping has also reduced the distribution of some mallee communities in their eastern most occurrences (Benson 1989). Conservation recommendations for remnant mallee areas include maintaining roadside and fenceline corridors for habitat and erosion control and fencing to exclude stock (Morgan & Terrey 1992). *Eucalyptus intertexta*, a component of the Warranary Hill Woodland Complex (Community 29) in the far north-east of the mapped area is very poorly conserved (Benson 1988). Some *Maireana pyramidata* and *Maireana sedifolia* is conserved within Kinchega and Mungo National Parks although these species remain unconserved on the Hay Plain.

Conservation of species

The conservation status of species on the Hay Plain and south-western New South Wales generally is poor. Forty-four per cent of all vulnerable plants in New South Wales occur on the western slopes and plains (Benson 1989, 1991). This is due to the widespread environmental modification since European settlement and because there are relatively few reserves in these areas compared to the eastern part of the state. Five species that once existed on the Western Plains botanical subdivisions are now extinct while at least ten now only occur interstate (Benson 1989). Seven rare species have been recorded from the Hay Plain while one species, *Ptilotus extenuatus*, is presumed extinct (Briggs & Leigh 1988). Species of particular conservation significance within the mapped areas are listed in Table 5.

More knowledge of the population biology of these restricted, threatened and rare species is needed, starting with surveying their distributions and protecting populations in reserves where possible.

Conservation recommendations

The clearing of land for irrigation and cropping and the prevention of regeneration of native species due to grazing pressure are the major factors contributing to vegetation loss on the Hay Plain. In such an altered area, any relatively intact remnants of natural vegetation need to be carefully managed. No further clearing should be permitted without regional assessment. The regeneration of perennial species is essential to achieve landscape stability within the pastoral areas (Morgan & Terrey 1992).

It is clear that high stocking rates and grazing pressure from other introduced and native herbivores will continue to be most detrimental to the survival of the remaining natural vegetation. The prevention of regeneration in many communities by grazing pressure has serious ramifications for their future survival. To ensure the long-term stability of the vegetation and soil, management should aim to utilise the annual element of the pasture, while maintaining the perennial component (Dalton 1988). Continuing irrigation practices and tree clearing may leave riparian and floodplain vegetation vulnerable to dieback from rising salinity.

Options for conserving native vegetation range from the gazettement of fully managed national parks and nature reserves in appropriate areas, to the more immediate action of vegetation retention and protection by individual land managers through

altered management practices. Because of the remnant nature of native vegetation on the Hay Plain today, carefully chosen and managed reserves should be incorporated into any future land management plans for the area. Conservation programs will require the acquisition and establishment of reserves in which there is complete eradication of all stock and feral herbivores, and control of native herbivores. The concept of individual custodianship of natural resources may be the key to the future survival of remnant vegetation communities and habitats in much of south-western New South Wales.

Acknowledgments

This project was jointly funded by the Natural Resources Management Strategy of the Murray-Darling Basin Ministerial Council, and the Royal Botanic Gardens, Sydney, over its three-and-a-half years duration. I wish to acknowledge the significant contribution of Dr Marilyn Fox, who initiated the project and successfully obtained the grant as well as continued funding. Marilyn Fox was also responsible for initial project direction and fieldwork, and for providing her knowledge of the area and unpublished site data. Many thanks to the staff of the Ecology Section at the Royal Botanic Gardens, namely Doug Benson, John Benson, Judy Scott and Jocelyn Howell, for their continued assistance and support. The assistance of technical staff and botanists of the National Herbarium of NSW in plant identifications, particularly Barbara Wiecek and Bob Coveny, is gratefully acknowledged. Rob Denham, Geoff Robertson, Judy Scott, Barbara Wiecek, Peter Higgs and Vicki Logan assisted in the field. Thanks to Doug Benson, John Benson, Dr Lawrie Johnson, Dr Barbara Briggs, Barbara Wiecek, Ken Hill and Surrey Jacobs for critically reviewing the text. Rob Denham, Rob Scriven and Roger Oxley of the Hay and Deniliquin branches of the Soil Conservation Service of New South Wales (now the NSW Department of Conservation and Land Management) provided valued expertise and advice and unpublished data on saltbush distribution. Thanks go also to Peter Milliken of the Hay Landcare group, and Martin Driver of Greening Australia, for imparting local knowledge. I wish to thank John Muir (Hay branch of the Department of Agriculture) and staff of the Griffith branch of the Department of Agriculture, for soil analyses and the loan of an EM-38 salinity meter. I am most grateful to the live-in staff of Willandra National Park for accommodation and access to areas within the park. Particular thanks are due to the numerous landholders across the Hay Plain for providing access to their properties and valuable local knowledge.

References

- Abraham, N.A. (1987) Scald revegetation trends in the Riverine Plain. *Journal of Soil Conservation of New South Wales*. 43(2): 73-77.
- Alchin, B.M. (1974) Species trials in semi arid south-western New South Wales, 1956-1971. *Journal of the Soil Conservation Service of N.S.W.* 30: 46-73.
- Allen, B. (1979) Red gum country-the forest of the floodplains. *Forest and Timber* 15(3): 2-4.
- Appleby, M.L., McDougall, K.L and Barlow, T.J. (1991) *Conservation research statement for Swainsona plagiotropis* F. Muell. (Red Swainson-pea) (NSW National Parks and Wildlife Service, Western Region: Broken Hill).
- Barlow, B.A. (1981) The Australian Flora: its origin and evolution. In Bureau of Flora and Fauna, Canberra *Flora of Australia* Volume 1, Introduction (Australian Government Publishing Service: Canberra).
- Beadle, N.C.W. (1948) *The vegetation and pastures of western New South Wales with special reference to soil erosion* (Government Printer: Sydney).

- Beadle, N.C.W. (1948b) Studies in wind erosion. II. Some characteristics of scalded surfaces. *Journal of the Soil Conservation Service of New South Wales* 4: 64–68.
- Beadle, N.C.W. (1981) *The Vegetation of Australia* (Cambridge University Press: London).
- Beadle, N.C.W. and Costin, A.B. (1952) Ecological classification and nomenclature. *Proceedings of the Linnean Society of New South Wales* 77: 61–82.
- Benson, J.S. (1988) Conservation of flora in western New South Wales. *National Parks Journal* 32(3): 16–22.
- Benson, J.S. (1989) Establishing priorities for the conservation of rare and threatened plants and plant associations in New South Wales. In M. Hicks and P. Eiser (eds) *The conservation of threatened species and their habitats* (Australian Committee for IUCN: Canberra).
- Benson, J.S. (1991) The effect of 200 years of European settlement on the vegetation and flora of New South Wales. *Cunninghamia* 2(3): 343–370.
- Beveridge, P. (1883) Of the Aborigines inhabiting the Great Lacustrine and Riverine Depression of the Lower Murray, Lower Murrumbidgee, Lower Lachlan and Lower Darling. *Proceedings of the Royal Society of New South Wales* 17: 19–74.
- Bowler, J.M. (1967) Quaternary chronology of the Goulburn Valley sediments and their correlation in south-eastern Australia. *Geological Society of Australia Journal* 14: 287–292.
- Bowler, J.M. (1980) Quaternary chronology and paleohydrology in the evolution of mallee landscapes. In R.R. Storrer and M.E. Stannard (eds) *Aeolian landscapes in the semi-arid zone of south eastern Australia* (Australian Society of Soil Science Inc., Riverina Branch: Wagga Wagga).
- Bowler, J.M. and Harford, L.B. (1966) Quaternary tectonics and the evolution of the Riverine Plain near Echuca, Victoria. *Geological Society of Australia Journal* 13: 339–354.
- Brickhill, J. (1985) Vegetation by geographic regions. Southern Riverina. *Review of Nature Conservation Programmes, Paper No. 13* (New South Wales National Parks and Wildlife Service: Griffith District).
- Briggs, J.D. and Leigh, J.H. (1988) *Rare or threatened Australian plants* Special Publication 14 (Australian National Parks and Wildlife Service: Canberra).
- Bureau of Meteorology (1955) *Climatological survey: Region 19 – Murray Darling New South Wales* (Director of Meteorology: Melbourne).
- Bureau of Meteorology (1988) *Climatic averages Australia* (Australian Government Publishing Service: Canberra).
- Butler, B.E. (1950) A theory of prior streams as a causal factor of soil occurrence in the Riverine Plain of south-eastern Australia. *Australian Journal of Agriculture Research* 1: 231–252.
- Butler, B.E. (1956) Parna – an aeolian clay. *Australian Journal of Science* 18: 145–151.
- Butler, B.E. (1958) Depositional systems of the Riverine Plain of south eastern Australia in relation to soils. *Australian CSIRO Soils Bulletin* 10.
- Butler, B.E., Blackburn, G., Bowler, J.M., Lawrence, C.R., Newell, J.W. and Pels, S. (1973) *A geomorphic map of the Riverine Plain of south-eastern Australia* (Australian National University Press: Canberra).
- Calder, M. (1990) Nature conservation of mallee lands in Australia. In J.C. Noble, P.J. Joss and G.K. Jones (eds) *The mallee lands: a conservation perspective* (CSIRO: Melbourne).
- Chesterfield, C.J. and Parsons, R.F. (1985) Regeneration of three tree species in arid south-eastern Australia. *Australian Journal of Botany* 33: 715–732.
- Clift, D.K. (1989) Saltbush dieback and regeneration on the Riverine Plain of south-eastern Australia. In W.S. Semple (ed.) *Further comments on the dieback and regeneration of Bladder Saltbush. Technical Report No. 23* (Soil Conservation Service of New South Wales).
- Clift, D.K., Semple, W.S. and Prior, J.C. (1987) A survey of Bladder Saltbush (*Atriplex vesicaria* Heward ex Benth.) dieback on the Riverine Plain of south-eastern Australia from the late 1970's to 1983. *Australian Rangelands Journal* 9(1): 39–48.
- Clift, D.K., Dalton, K.L. and Prior, J.C. (1989) Bladder Saltbush (*Atriplex vesicaria* Heward ex Benth.) regeneration on the Riverine Plain of south-eastern Australia since 1983. *Australian Rangelands Journal* 11(1): 31–39.
- Condon, R.W. and Stannard, M.E. (1957) Erosion in western New South Wales. II. Forms of wind erosion. *Journal of the Soil Conservation Service of New South Wales* 13: 17–26.
- Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. and Leigh, J.H. (1981) *Plants of Western New South Wales* (Government Printer: Sydney).
- Cunningham, G.M. and Milthorpe, P.L. (1981) The vascular plants of five exclosure sites in western New South Wales. *Cunninghamia* 1(1): 23–34.

- Dalton, K.L. (1988) A review of the information relevant to the saltbush plain rangelands of western New South Wales. *Technical Report No. 9* (Soil Conservation Service of New South Wales).
- Denney, M. (1992) *Historical and ecological study of the effects of European settlement on inland NSW* (Nature Conservation Council of New South Wales: Sydney).
- Edwards, K. (1979) Rainfall in New South Wales with special reference to soil conservation. *Soil Conservation Technical Handbook No. 3*. (Soil Conservation Service of New South Wales).
- Eldridge, D.J. (1990) Soils. In *Hay district technical manual* (Soil Conservation Service of New South Wales).
- Finlayson, M. and Moser, M. (eds) (1991) *Wetlands*. International Waterfowl and Wetlands Research Bureau (Facts on File: Oxford, New York).
- Flood, J. (1990) *The richness of ancient Australia* (University of Queensland Press: Brisbane).
- Fox, M.D. (1990) Composition and richness of New South Wales mallee. In J.C. Noble, P.J. Joss and G.K. Jones (eds) *The mallee lands: a conservation perspective* (CSIRO: Melbourne).
- Fox, M.D. (1991) The natural vegetation of the Ana Branch-Mildura 1:250 000 map sheet (New South Wales). *Cunninghamia* 2(3): 443-493.
- Goldbery, R. and West, J.L. (1968) *Lachlan 1:500 000 geological series* (NSW Department of Mines: Sydney).
- Graetz, R.D. and Wilson, A.D. (1984) Saltbush and bluebush. In G.N. Harrington, A.D. Wilson and M.D. Young (eds) *Management of Australia's rangelands* (CSIRO: Melbourne).
- Grant, T.C. (1989) *History of forestry in New South Wales 1788 to 1988* (Forestry Commission of New South Wales: Sydney).
- Harden, G.J. (ed.) (1990-1992) *Flora of New South Wales* Vol. 1-3 (New South Wales University Press: Sydney).
- Harris, W.J. (1939) The physiography of the Echuca district. *Proceedings of the Royal Society of Victoria* 51: 45-60.
- Hawkins, C.A. and Walker, P.H. (1956) Study of layered sedimentary materials in the Riverine Plain. *Royal Society of New South Wales Journal and Proceedings* 90: 110-127.
- Hodgkinson, K.C. (1983) Influence of fire on arid land vegetation and some implications for management. In J. Messer and G. Mosley (eds) *What future for Australia's arid lands?* (Australian Conservation Foundation: Melbourne).
- Hodgkinson, K.C., Harrington, G.N., Griffin, G.F., Noble, J.C. and Young, M.D. (1984) Management of vegetation with fire. In G.N. Harrington, A.D. Wilson and M.D. Young (eds) *Management of Australia's rangelands* (CSIRO: Melbourne).
- Jacobs, S. and Pickard, J. (1981) *Plants of New South Wales* (Government Printer: Sydney).
- Knowles, G.H. and Condon, R.W. (1951) The perennial saltbush *Atriplex vesicarium* Heward. *Journal of Soil Conservation of New South Wales* 7: 123-131.
- Lawrie, J.W. and Stanley, R.J. (1980) Representative land systems of mallee lands in the Western Division of New South Wales. In R.R. Storrier and M.E. Stannard (eds) *Aeolian landscapes in the semi-arid zone of south eastern Australia* (Australian Society of Soil Science Inc., Riverina Branch: Wagga Wagga).
- Leigh, J.H. and Mulham, W.E. (1965) *Pastoral plants of the Riverine Plain* (The Jacaranda Press: Melbourne).
- Leigh, J.H. and Mulham, W.E. (1966a) Selection of diet by sheep grazing semi-arid pastures on the Riverine Plain. 1. A Bladder Saltbush (*Atriplex vesicaria*)-Cotton Bush (*Kochia aphylla*) community. *Australian Journal of Experimental Agriculture and Animal Husbandry* 6: 460-467.
- Leigh, J.H. and Mulham, W.E. (1966b) Selection of diet by sheep grazing semi-arid pastures on the Riverine Plain. 2. A Cotton Bush (*Kochia aphylla*)-grassland (*Stipa variabilis*-*Danthonia caespitosa*) community. *Australian Journal of Experimental Agriculture and Animal Husbandry* 6: 468-474.
- Leigh, J.H. and Mulham, W.E. (1967) Selection of diet by sheep grazing semi-arid pastures on the Riverine Plain. 3. A Bladder Saltbush (*Atriplex vesicaria*)-pigface (*Disphyma australe*) community. *Australian Journal of Experimental Agriculture and Animal Husbandry* 7: 421-425.
- Leigh, J.H. and Mulham, W.E. (1977) Vascular plants of the Riverine Plain of New South Wales with notes on distribution and pastoral use. *Telopea* 1(4): 225-293.
- Leigh, J.H. and Noble, J.C. (1972) *Riverine Plain of New South Wales: its pastoral and irrigation development* (CSIRO Division of Plant Industry: Canberra).

- Leigh, J.H. and Noble, J.C. (1981) The role of fire in the management of rangelands in Australia. In A.M. Gill, R.H. Groves and I.R. Noble (eds) *Fire and the Australian biota* (Australian Academy of Science: Canberra).
- Leigh, J.H. and Wilson, A.E. (1970) Utilisation of *Atriplex* species by sheep. In R. Jones (ed.) *The Biology of Atriplex* (CSIRO: Canberra).
- Lunnon, P. (1988) *Willandra National Park draft plan of management* (New South Wales National Parks and Wildlife Service: Sydney).
- Mabbutt, J.A. (1980) Some general characteristics of aeolian landscapes. In R.R. Storrier and M.E. Stannard (eds) *Aeolian landscapes in the semi-arid zone of south eastern Australia* (Australian Society of Soil Science Inc., Riverina Branch: Wagga Wagga).
- Margules and Partners Pty Ltd, P. and J. Smith Ecological Consultants and Department of Conservation Forests and Lands Victoria (1990) *River Murray riparian vegetation study* (Murray-Darling Basin Commission).
- Martin, H.A. (1978) Evolution of the Australian flora and vegetation through the Tertiary: evidence from pollen. *Alcheringa* 2: 181-202.
- Martin, H.A. (1981) The Tertiary Flora. In A. Keast (ed.) *Ecological Biogeography of Australia* (Dr. W. Junk bv Publishers: London).
- Moore, C.W.E. (1953) The vegetation of the south-eastern Riverina, New South Wales. I. The climax communities. *Australian Journal of Botany* 1:485-547.
- Morgan, G. and Terrey, J. (1992) *Nature conservation in western New South Wales* (National Parks Association of NSW Inc.: Sydney).
- Muirhead, W.A. and Jones, R.M. (1966) Species trials in the semi-arid south-west of New South Wales. II. Native shrub trials in the Hay district. *Journal of the Soil Conservation Service of N.S.W.* 22: 138-146.
- Mulham, W.E. and Jones, D.E. (1981) Vascular plants of the Riverine Plain of New South Wales - supplementary list. *Telopea* 2(2): 197-213.
- Mullins, B., Cook, T. and Gerritsen, J. (1982) *Aboriginal lore of the western plains* (Mulavon Pty Ltd: Sydney).
- Murray-Darling Basin Ministerial Council (1987) *Murray-Darling Basin Environmental Resources Study* (Murray-Darling Basin Ministerial Council: Canberra).
- National Climate Centre (1992) *Report of monthly and yearly rainfall* (Bureau of Meteorology: Melbourne).
- NSW Department of Lands (1987) *Aboriginal New South Wales* (Central Mapping Authority: Bathurst).
- Noble, J.C. and Mulham, W.E. (1980) The natural vegetation of aeolian landscapes in semi-arid south-eastern Australia. In R.R. Storrier and M.E. Stannard (eds) *Aeolian landscapes in the semi-arid zone of south eastern Australia* (Australian Society of Soil Science Inc., Riverina Branch: Wagga Wagga).
- Noble, J.C., Smith, A.W. and Leslie, H.W. (1980) Fire in the mallee shrublands of western New South Wales. *Australian Rangelands Journal* 2(1): 104-114.
- Noble, J.C. and Whalley, R.D.B. (1978) The biology and autecology of *Nitraria* L. in Australia. II. Seed germination, seedling establishment and response to salinity. *Australian Journal of Ecology* 3: 165-177.
- Norris, E.H. and Thomas, J. (1991) Vegetation on rocky outcrops and ranges in central and south-western New South Wales. *Cunninghamia* 2(3):411-441.
- Noy-Meir, I. (1974) Multivariate analysis of the semi-arid vegetation in south-eastern Australia. II. Vegetation catenae and environmental gradients. *Australian Journal of Botany* 22: 115-140.
- Offenberg, A.C. (1969) *Urana 1:500 000 geological series* (NSW Department of Mines: Sydney).
- Osborn, T.G.B., Wood, G.J. and Paltridge, T.B. (1932) On the growth and reaction to grazing of the perennial saltbush, *Atriplex vesicarium*. An ecological study of the biotic factor. *Proceedings of the Linnaean Society of New South Wales* 57: 377-402.
- Pels, S. (1964a) The present and ancestral Murray River System. *Australian Geographic Studies* 2(2): 111-119.
- Pels, S. (1964b) Quaternary sedimentation by prior streams on the Riverine Plain south-west of Griffith, New South Wales. *Journal and Proceedings, Royal Society of New South Wales* 97: 107-115.

- Pels, S. (1969a) The Murray Basin. In G.H. Packham (ed.) *The Geology of New South Wales. Journal of the Geological Society of New South Wales* 16: 499–511.
- Pels, S. (1969b) Radio-carbon datings of ancestral river sediments on the Riverine Plain of south-eastern Australia and their interpretation. *Journal and Proceedings, Royal Society of New South Wales* 102: 189–195.
- Pressey, R.L. (1988) Wetlands of western New South Wales: characteristics, conservation and management. *National Parks Journal* 32(3): 23–30.
- Pressey, R.L., Bell, F.C., Barker, J., Rundle, A.S. and Belcher, C.A. (1984) *Bio-physical features of the Lachlan-Murrumbidgee confluence, south-western New South Wales* (New South Wales National Parks and Wildlife Service).
- Pressey, R.L., Cohn, J.S. and Porter, J.L. (1990) Vascular plants with restricted distributions in the Western Division of New South Wales. *Proceedings of the Linnean Society of New South Wales* 112: 213–227.
- Ratcliffe, F.N. (1936) Soil drift in the arid pastoral areas of South Australia. *Australian CSIR Pamphlet No. 64*.
- Rhodes, D.W. (1990) Climate. In *Hay district technical manual* (Soil Conservation Service of New South Wales).
- Rixon, A.J. (1970) Cycling of nutrients in a grazed *Atriplex vesicaria* community. In R. Jones (ed.) *The biology of Atriplex* (CSIRO: Canberra).
- Robards, G.E., Leigh, J.H. and Mulham, W.E. (1967) Selection of diet by sheep grazing semi-arid pastures on the Riverine Plain. 4. A grassland (*Danthonia caespitosa*) community. *Australian Journal of Experimental Agriculture and Animal Husbandry* 7: 426–433.
- Schumm, S.A. (1968) River adjustment to altered hydrologic regimen - Murrumbidgee River and paleochannels, Australia. *Geological Survey Professional Paper 598* (U.S. Department of the Interior).
- Scott, J.A. (1992) The natural vegetation of the Balranald–Swan Hill area. *Cunninghamia* 2(4): 597–652.
- Scriven, R.N. (1988a) A review of information relevant to the mallee rangelands of western New South Wales. *Technical Report No. 1* (Soil Conservation Service of New South Wales).
- Scriven, R.N. (1988b) A review of information relevant to the belah and bluebush rangelands of western New South Wales. *Technical Report No. 10* (Soil Conservation Service of New South Wales).
- Sample, W.S. (1986) Plant species lists from four enclosure sites in the Hay district of south-western New South Wales. *Cunninghamia* 1(4): 491–502.
- Sample, W.S. (1987a) Vascular plants of a paired grazed and ungrazed site on a prior stream in south-western N.S.W. *Western Region Technical Bulletin No. 29* (Soil Conservation Service of New South Wales).
- Sample, W.S. (1987b) Prior streams and Queel Queel gums – regeneration areas revisited. *Journal of Soil Conservation* 43(1): 38–43.
- Sample, W.S. (1989) Further comments on the dieback and regeneration of Bladder Saltbush. *Technical Report No. 23* (Soil Conservation Service of New South Wales).
- Sample, W.S. (1990) Introduction, Geology, Landforms, Vegetation, Land Use. In *Hay district technical manual* (Soil Conservation Service of New South Wales).
- Sample, W.S. and Eldridge, D.J. (1989) The physical and vegetation resources of the aeolian landscapes of far south-western NSW. *Technical Report No. 14* (Soil Conservation Service of New South Wales).
- Soil Conservation Service of New South Wales (unpubl.) A survey of *Atriplex vesicaria* extent conducted in 1987, including 1:250 000 maps for Hay and Booligal and questionnaires from individual landholders. Held at the Hay branch of the Soil Conservation Service of New South Wales (now the NSW Department of Conservation and Land Management).
- Somerville, J. (1988) Conservation of River Red Gums in New South Wales. *National Parks Journal* 32(3): 31–33.
- Specht, R.L. (1981) Foliage projective cover and standing biomass. In A.N. Gillson and D.J. Anderson (eds) *Vegetation classification in Australia* (Australian National University Press: Canberra).
- Stannard, M.E. (1958) Erosion survey of the south-west Cobar peneplain. *Journal of the Soil Conservation Service of New South Wales* 14(1): 30–45.
- Stannard, M.E. (1963) Erosion survey of the central east-Darling region. *Journal of the Soil Conservation Service of New South Wales* 19(1): 17–28.

- Sturt, C. (1833) *Two expeditions into the interior of southern Australia, during the years 1828, 1829, 1830 and 1831, with observations on the soil, climate and general resources of the colony of New South Wales* (Smith, Elder and Company: London).
- Treloar, G.K. (1959) Some factors affecting seedling survival of *Eucalyptus largiflorens* F. Muell. *Australian Forestry* 23: 46–48.
- Walker, J. and Hopkins, M.S. (1990) Vegetation. In R.C. McDonald, R.F. Isbell, J.G. Speight, J. Walker and M.S. Hopkins (eds) *Australian soil and land survey field handbook* (Inkata Press: Melbourne).
- Walker, P.J. (ed.) (1991) Land systems of western New South Wales. *Technical Report No. 25* (Soil Conservation Service of New South Wales).
- Wisniewski, J.E. and Parsons, R.F. (1986) Regeneration of *Heterodendrum* in arid south-eastern Australia. *Proceedings of the Royal Society of Victoria* 98(3): 87–95.
- Wilson, A.D. and Graetz, R.D. (1979) Management of semi-arid and arid rangelands of Australia. In B.H. Walker (ed.) *Management of semi-arid ecosystems* (Elsevier Scientific: New York).
- Wilson, A.D. and Harrington, G.N. (1984) Grazing ecology and animal production. In G.N. Harrington, A.D. Wilson and M.D. Young (eds) *Management of Australia's rangelands* (CSIRO: Melbourne).
- Wilson, A.D., Harrington, G.N. and Beale, I.F. (1984) Grazing management. In G.N. Harrington, A.D. Wilson and M.D. Young (eds) *Management of Australia's rangelands* (CSIRO: Melbourne).
- Wilson, K.L. and Johnson, L.A.S. (1989) Casuarinaceae. In Bureau of Flora and Fauna, Canberra *Flora of Australia* Volume 3, Hamamelidales to Casuarinales (Australian Government Publishing Service: Canberra).

APPENDIX 1

Species list for communities identified on the Booligal, Hay and Deniliquin-Bendigo 1:250 000 map sheets. Key to communities on pages 22–23.

Key

- a Leigh, J.H. and Mulham, W.E. (1977) Vascular plants of the Riverine Plain of New South Wales with notes on distribution and pastoral use. *Telopea* 1(4): 225–293 and Mulham, W.E. and Jones, D.E. (1981) Vascular plants of the Riverine Plain of New South Wales – supplementary list. *Telopea* 2(2): 197–213.
 - b Cunningham, G.M. and Milthorpe, P.L. (1981) The vascular plants of five exclosures in western New South Wales. *Cunninghamia* 1(1): 23–34. (*Soil Conservation Service of New South Wales experimental exclosures 'Trida', 'Micabil', 'Sayers Lake' and 'Booberoi'*).
 - c Semple, W.S. (1986) Plant species lists from four exclosure sites in the Hay district of south-western New South Wales. *Cunninghamia* 1(4): 491–502. (*Soil Conservation Service of New South Wales experimental exclosures 'Jim Barren', 'One Tree', 'Paradise' and 'Tchelely'*).
 - d Pressey, R.L., Bell, F.C., Barker, J., Rundle, A.S. & Belcher, C.A. (1984) *Bio-physical features of the Lachlan-Murrumbidgee confluence, south-western New South Wales*. (NSW National Parks & Wildlife Service). (*Great Cumbung Swamp area*).
 - e Margules and Partners Pty Ltd, P. & J. Smith Ecological Consultants and Department of Conservation Forests and Lands Victoria (1990) *Riparian vegetation of the River Murray* (Murray-Darling Basin Commission). (*Murray River Section 4*).
- [] synonymous names
* exotic
extension of known range in NSW (specimen held National Herbarium of NSW).
! new record for NSW (unsubstantiated).
@ ROTAP listed (Briggs & Leigh 1988).
% western division plants with restricted distribution (Pressey *et al.* 1990).

Botanical Name	Community			Other Records		
	Forest	Woodland	Mallee	Shrubland	Grassland	
PTERIDOPHYTES						
Aspleniaceae						
<i>Pleurosorus subglandulosus</i>		29				
Azollaceae						
<i>Azolla filiculoides</i>						de
<i>A. filiculoides</i> var. <i>rubra</i>						a
<i>A. pinnata</i>						d

Dennstaedtiaceae <i>Peridium esculentum</i>	16				
Isoetaceae <i>Isoetes muelleri</i>					a
Marsileaceae <i>Marsilea angustifolia</i> <i>M. drummondii</i>	1	2 25 28	11 12 18 21	13 23 26	a d
Ophioglossaceae <i>Ophioglossum lusitanicum</i>					
Pteridaceae <i>Pteris tremula</i>					a
Sinopteridaceae <i>Cheilanthes austrotenuifolia</i> [<i>C. sieberi</i> subsp. <i>tenuifolia</i>] <i>C. sieberi</i> subsp. <i>sieberi</i> [<i>C. tenuifolia</i> subsp. <i>sieberi</i>]		29			a
GYMNOSPERMS					
Cupressaceae <i>Callitris glaucophylla</i> <i>C. gracilis</i> subsp. <i>murrayensis</i> [<i>C. preissii</i> subsp. <i>murrayensis</i>]		4 16 17 24 27 29 16 24	3d 8 11		e
ANGIOSPERMS-DICOTYLEDONS					
Alzooaceae <i>Disphyma crassifolium</i> subsp. <i>clavellatum</i> [<i>D. clavellatum</i>] * <i>Galenia pubescens</i> <i>Glinus lotoides</i> * <i>Mesembryanthemum crystallinum</i> * <i>M. nodiflorum</i> <i>Sarcocolla praecox</i> <i>Tetragonia tetragonoides</i> * <i>Zaleya galericulata</i> subsp. <i>australis</i>	1	2 28 2	8 8 11 12 21	13	a a ac abc

Botanical Name	Community		Other Records			
	Forest	Woodland	Mallee	Shrubland	Grassland	
Amaranthaceae						
* <i>Alternanthera angustifolia</i>						
<i>A. denticulata</i>	1	2 25 28 2		11 18		ab
<i>A. nodiflora</i>						
* <i>A. pungens</i>						a
* <i>Amaranthus albus</i>						a
* <i>A. hybridus</i>						a
<i>A. macrocarpus</i>						
* <i>A. retroflexus</i>	1	2 28				a
* <i>A. viridis</i>						a
<i>Ptilotus atriplicifolius</i> var. <i>atriplicifolius</i>						a
<i>P. erubescens</i>						a
<i>P. gaudichaudii</i> var. <i>parviflorus</i>		4 16				a
<i>P. macrocephalus</i>						
<i>P. nobilis</i>		25				a
<i>P. polystachyus</i> var. <i>polystachyus</i>		25				
<i>P. semilanatus</i>						a
<i>P. spathulatus</i>		4 16 25 29				
Anacardiaceae						
* <i>Schinus areira</i>						ad
Apiaceae						
* <i>Ammi majus</i>						a
* <i>Apium leptophyllum</i>						a
<i>Daucus glochidiatus</i>						
<i>Eryngium plantagineum</i>		25 27 28		8 11 12 21 21		a
<i>E. rostratum</i>						a
* <i>Foeniculum vulgare</i>						a
<i>Hydrocotyle laxiflora</i>						
Asteraceae						
* <i>Acroptilon repens</i>						a
<i>Actinobole uliginosum</i>						
<i>Angianthus brachypappus</i>						
<i>A. tomentosus</i>		4 16 29	3b	19		b

Other Records

Community

Botanical Name

Grassland

Shrubland

Mallee

Woodland

Forest

Asteraceae (cont'd)

Chrysanthemoides moniliferaChrysocephalum apiculatum*[*Helichrysum apiculatum*]*Chthonocephalus pseudevax***Cichorium intybus***Cirsium vulgare***Coryza albida***C. bonariensis**Cotula australis***C. bipinnata***C. coronopifolia*! *Craspedia glauca*! *C. uniflora**C. variabilis**Cymbonotus lawsonianus**C. preissianus***Cynara cardunculus**Eclipta platyglossa**Epilates australis**E. cunninghamii**Eriochlamys behrii***Gnaphalium coarctatum**G. gymnocephalum**G. sphaericum**Gnephosis arachnoidea***Hedynopsis rhagadioloides* subsp. *cretica**Helichrysum leucopsideum**H. rutidolepis*! *H. semipapposum**Hyalosperma glutinosum* subsp. *glutinosum*[*Helipterum hyalospermum*]*H. praecox*[*Helipterum praecox*]*H. semisterile*[*Helipterum jessenii*]

a

ab

a

d

acd

13 23

23

e

a

e

a

a

ae

ab

ac

a

ae

bce

b

e

a

a

ac

ac

21 22

11 18 21

11 19 21 22

3b

21

3b

25

2 16 25 27

25

25

29

2 28

4 16 25

25

* <i>Hypochoeris glabra</i>	25 29			11 21		
* <i>H. radicata</i>	4 16			21		ab
<i>Isoetopsis graminifolia</i>						
<i>Ixiolaena leptolepis</i>				8 11 21	13	
<i>I. tomentosa</i>				11 21 22		
* <i>Lactuca saligna</i>	2 16 24 25					
* <i>L. serriola</i>						ae
* <i>Leontodon taraxacoides</i>	25					bce
# <i>Leptorhynchus elongatus</i>	24					ae
<i>L. panaetioides</i>				11 21		
<i>L. squamatus</i>				21		a
<i>Leucochrysium molle</i> [<i>Helipterum molle</i>]						
<i>Microseris lanceolata</i>						
<i>Millotia myosotidifolia</i>	29					ac
* <i>M. perpusilla</i>						
<i>Minuria cunninghamii</i>			3d	8 11 12 19 21 22		a
<i>M. denticulata</i>						
<i>M. integririma</i>						
<i>M. leptophylla</i>	25 29					abc
<i>Myriocephalus rhizocephalus</i>	25			18 19 21		abc
<i>M. stuartii</i>			3d			c
<i>Olearia pimeleoides</i>			3b 3d			
* <i>Onopordum acanthium</i>						a
* <i>O. acaulon</i>						ac
* <i>Picris echioides</i>						ace
* <i>P. hieracioides</i>						d
<i>Podolepis canescens</i>						a
<i>P. muelleri</i>				11 21		
* <i>Podospermum resedifolium</i> [* <i>Scorzonera laciniata</i>]				11		
<i>Pogonolepis muelleriana</i>						
<i>P. stricta</i>						ab
<i>Pseudognaphalium luteo-album</i>		1				c
<i>Pycnosorus chrysanthus</i> [<i>Craspedia chrysanth</i>]						ab
<i>P. globosus</i> [<i>Craspedia globosa</i>]						
<i>P. pleiocephalus</i> [<i>Craspedia pleiocephala</i>]	4 16 25 29			8 21		ac

Asteraceae (cont'd)**Reichardia tingitana**Rhodanthe corymbiflora*
[*Helipterum corymbiflorum*]*R. diffusa**R. floribunda*
[*Helipterum diffusum*]*R. moschata*
[*Helipterum floribundum*]*R. polygalifolia*
[*Helipterum moschatum*]*R. pygmaea*
[*Helipterum polygalifolium*]*R. stuartiana*
[*Helipterum pygmaeum*]*R. uniflora*
[*Helipterum stuartianum*]**Scolymus hispanicus**Senecio cunninghamii* var. *cunninghamii**S. glossanthus**S. hispidulus* var. *dissectus**S. lautus* subsp. *dissectifolius**S. linearifolius**S. platylepis**S. quadridentatus**S. runcinifolius**Sigesbeckia orientalis* subsp. *orientalis***Silybum marianum**Solenogyne bellioides**S. dominii***Sonchus asper* subsp. *glaucescens**S. hydrophilus***S. oleraceus**Stuartina muelleri***Taraxacum officinale***Tragopogon porrifolius**Triptilodiscus pygmaeus*[*Helipterum australe*]

Grassland

Shrubland

Mallee

Woodland

a

26

8 11 18 19 21 22

c

8 11 21

abc

ab

11 21

a

a

d

23

18

11 21

a

11 21

a

21

18 21

a

a

a

a

d

e

26

11 21

ab

a

a

25 29

[illegible]

Other Records

Community

Botanical Name

Grassland

Shrubland

Mallee

Woodland

Forest

a

a

bc

a

a

a

c

a

ae

b

bc

ac

a

ab

a

ae

ade

ae

a

b

a

e

a

ae

11 18 19

8

21

19 21

29

29

25

28

29

2 16 25 27

28

25

25 29

*Cardaria draba

*Carrichtera annua

*Coronopus didymus

%Cuphonotus humistratus

*Diplotaxis tenuifolia

Geococcus pusillus

Harmsiodoxa blennodioides

H. brevipes var. brevipes

*Hirschfeldia incana

*Lepidium africanum

L. fasciculatum

@L. monoplocoides

L. papillosum

L. pseudohyssopifolium

!L. rotundum

L. sagittulatum

%Menkea australis

%Pachymitus cardaminoides

Phlegmatospermum cochlearinum

*Rapistrum rugosum

*Raphanus raphanistrum

%Rorippa eustylis

R. laciniata

*R. palustris

*Sinapis alba

*Sisymbrium altissimum

*S. ensimoides

*S. irio

*S. officinale

*S. orientale

Stenopetalum lineare

%S. velutinum

1

1

1

1

1

1

1

1

Callitrichaceae

Callitriche cyclocarpa

C. sonderi

*C. stagnalis

Campanulaceae

- Wahlenbergia communis*
- W. fluminalis*
- W. gracilentia*
- W. gracilis*
- W. luteola*
- W. stricta* subsp. *alterna*
- W. stricta* subsp. *stricta*

abce
acde
c
abce

1

25
25
4
4 16 27 29

11

Cannabaceae

- **Cannabis sativa*

a

Capparidaceae

- Apophyllum anomalum*

28

Caryophyllaceae

- **Cerastium glomeratum*
- **Moenchia erecta*
- **Petrorhagia velutina*
- **Polycarpon tetraphyllum*
- Scleranthus minusculus*
- **Silene gallica*
- **Spargula pentandra*
- **Spargularia diandra*
- **S. rubra*
- Stellaria angustifolia*
- **S. media*
- **Vaccaria pyramidata*

ae
a
ae
a
a
a
ac
ae
a

1

2 4 16 25 28

3d

8 11 18 21 22

1

Casuarinaceae

- Allocasuarina luehmannii*
- Casuarina cristata*
- C. obesa*
- C. pauper*
- C. pauper/C. cristata intergrades*

16 17 24
16
4 16 17 28 29
28

8p

e

Chenopodiaceae

- Atriplex angulata*
- A. conduplicata*
- A. eardleyae*
- A. holocarpa*

8
21
11

ab

Botanical Name	Community		Other Records			
	Forest	Woodland	Mallee	Shrubland	Grassland	
Chenopodiaceae (cont'd)						
<i>Atriplex infrequens</i>						b
<i>A. intermedia</i>		2 16 25 27		8 11 12 18 21		b
<i>A. leptocarpa</i>		2 28		8 8p 11 12 18 19 21	13	
<i>A. lindleyi</i>		2 16 25 27		8 11 19	13	
<i>A. nummularia</i>		2 16		8 11 12 18 19 21	13	
<i>A. pseudocampanulata</i>						d
<i>A. pumilio</i>		2 16 25 27 28		8 11 12 18 21		
<i>A. semibaccata</i>						a
<i>A. spinibractea</i>						ab
<i>A. spongiosa</i>		25 28	3d	11		
<i>A. stipitata</i>		2		18		
<i>A. suberecta</i>		2 4 25 28		8 8p 11 12 19 21 22	13	
<i>A. vesicaria</i>						a
* <i>Chenopodium album</i>						a
* <i>C. ambrosioides</i>						a
<i>C. auricomum</i>						a
<i>C. carinatum</i>						a
<i>C. cristatum</i>						c
<i>C. curvispicatum</i>		16		11		
[<i>Rhagodia gaudichaudiana</i>]						
<i>C. desertorum</i> subsp. <i>microphyllum</i>						a
<i>C. melanocarpum</i>						ab
* <i>C. multifidum</i>						a
* <i>C. murale</i>		2				
<i>C. nitraceum</i>	1	2 16 27 28		8 11 12 18 19	13 26	
<i>C. pumilio</i>	1	2		8		
<i>Dissocarpus biflorus</i> var. <i>biflorus</i>		4	3d	8 11 19	13	
<i>D. biflorus</i> var. <i>cephalocarpus</i>						b
<i>D. paradoxus</i>		4 27	3d	8 8p 11 19 21	26	
% <i>Dysphania littoralis</i>						a
<i>Einadia hastata</i>		2 16 25 27 28 29		8 11 12 19 21	13	ae
<i>E. nutans</i>	1					a
<i>E. polygonoides</i>						a
<i>E. trigonos</i>						
<i>Enchylaena tomentosa</i>		2 4 16 25 27 28	3d	8 11 19		

<i>Maireana aphylla</i>	4 16 25 27	8 11 19 21 22	13 26	
<i>M. appressa</i>		g		
<i>M. brevifolia</i>	4 16			
@ <i>M. cheelii</i>				ac
<i>M. coronata</i>	25			
<i>M. decalvans</i>	2 16 25 27 28	8 11 21	26	ae
<i>M. enchylaenoides</i>				a
<i>M. excavata</i>	28	8 21		
<i>M. georgei</i>	4 16			
<i>M. humilima</i>	25			
<i>M. lobiflora</i>				
<i>M. microcarpa</i>				
<i>M. microphylla</i>	2 16 25 27	11 21 22	26	ac
<i>M. pentagona</i>	2 4 16 27 28	8 8p 11 12 19		ab
<i>M. pyramidata</i>	25 27			
<i>M. sclerolaenoides</i>	4 27	8 8p		
<i>M. sedifolia</i>	25	8		
# <i>M. turbinata</i>	2 16 27	8 8p 11 12 18 19 21	13	
<i>Malacocera tricornis</i>	28	8 8p 11 12 21		
<i>Osteocarpum acropterum</i> var. <i>deminuta</i>				
[<i>Babbagia acroptera</i>]				
!O. <i>saluginosum</i>				ab
[<i>Threlkeldia saluginosa</i>]				
<i>Rhagodia spinescens</i>	2 4 16 17 25 27 28	8 8p 11 12 19 21	13 26	
<i>R. ulicina</i>		8 11 19 21	26	a
<i>Salsola kali</i>	2 16 27 28			ac
<i>Scleroblitum atriplicinum</i>				b
<i>Sclerolaena articulata</i>				
<i>S. bicornis</i> var. <i>bicornis</i>	2 28	8 11 12 19 21		
<i>S. bicornis</i> var. <i>horrida</i>	25			
<i>S. birchii</i>	28			
<i>S. brachyptera</i>	16 25 27 28	8 8p 11 12 19 21 22		b
<i>S. calcarata</i>				ab
<i>S. decurrens</i>				
<i>S. diacantha</i>		21		
<i>S. divaricata</i>		8 11 21		b
<i>S. eriacantha</i>		8 11 12		
<i>S. intricata</i>	2			ab
<i>S. lanicuspis</i>				
% <i>S. limbata</i>		11		

Botanical Name	Community			Other Records		
	Forest	Woodland	Mallee	Shrubland	Grassland	
Chenopodiaceae (cont'd)						
<i>Sclerolaena muricata</i>	1	2 16 24 25 27 28		11 12 18 19 21 22 11 21	13 26	
<i>S. muricata</i> var. <i>muricata</i>						
<i>S. muricata</i> var. <i>semiglabra</i>		16 24 25				
<i>S. muricata</i> var. <i>villosa</i>		2		11 21		bd
<i>S. obliquicuspis</i>						a
<i>S. paralleliscuspis</i>						bc
<i>S. patenticuspis</i>						
<i>S. stelligera</i>			3d	11 12 18 21	26	
<i>S. tricuspis</i>		16 25 27		8 8p 11 12 18 19 21 22 13		b
<i>S. uniflora</i>		2 16 25 27 28				b
<i>S. ventricosa</i>				11 12 19	13	
<i>Sclerostegia tenuis</i>						
Clusiaceae						
<i>Hypericum gramineum</i>						e
<i>H. japonicum</i>						a
* <i>H. perforatum</i>						a
Convolvulaceae						
<i>Calystegia sepium</i>		2 27		8		a
* <i>Convolvulus arvensis</i>		25 28		8 11 12 18 21 11	13	
<i>C. erubescens</i>	1					
<i>Cressa cretica</i>						
<i>Evolvulus alsinoides</i>		2				
<i>Wilsonia rotundifolia</i>						a
Crassulaceae						
<i>Crassula colorata</i> var. <i>acuminata</i>		16 25 29		8 11 19 21		a
<i>C. helmsii</i>						
<i>C. decumbens</i> var. <i>decumbens</i>			3d			ae
<i>C. peduncularis</i>		4 16 25 29				abce
<i>C. sieberiana</i>						
Cucurbitaceae						
* <i>Citrullus lanatus</i> var. <i>lanatus</i>						abc
* <i>Cucumis myriocarpus</i>		25 27 28		19	26	

**Ecballium elaterium*
Zehneria micrantha

Dilleniaceae

Hibbertia obtusifolia

Droseraceae

Drosera glanduligera
D. peltata

Elatinaceae

Bergia trimera
**Elatine gratioloides*

Euphorbiaceae

Beyleria viscosa
Chamaesyce dallachyana
C. drummondii
**Chrozophora tinctoria*
E. eremophila
**E. peplus*
E. planiticola
Phyllanthus lacunarius

Fabaceae-Caesalpinioideae

Senna artemisioides subsp. *circinnata*
[*Cassia circinnata*]
S. artemisioides nothosubsp. *coriacea*
[*Cassia eremophila* var. *coriacea*]
S. artemisioides subsp. *filifolia*
[*Cassia eremophila* var. *eremophila*]
S. artemisioides subsp. *petiolaris*
[*Cassia eremophila* var. *platypoda*]
S. artemisioides subsp. *zygophylla*
[*Cassia eremophila* var. *zygophylla*]
S. barclayana

Fabaceae-Faboideae

**Alhagi maurorum*
Bossiaea buxifolia
**Chamaecytisus palmensis*

a a a a a a a d a abc a a a a a a a

26 26

21 21

29 2 16 25 27 28

1

27

24

4 24

16

16 24 25

3d

3d

Botanical Name

Other Records

Grassland

Shrubland

Mallee

Community

Woodland

Forest

Fabaceae-Faboideae (cont'd)

Daviesia minosoides
Dillwynia cinerascens

D. sericea

Eutaxia diffusa

E. microphylla

**Genista linifolia*

Glycine clandestina

G. tabacina

Glycyrrhiza acanthocarpa

Lotus australis

**L. corniculatis*

L. cruentus

**Medicago lacinata*

**M. minima*

**M. polymorpha*

**M. praecox*

**M. sativa*

**M. truncatula*

! **Melilotus alba*

**M. indica*

**Prosopis glandulosa* var. *glandulosa*

**P. juliflora*

Psoralea cinerea

P. tenax

Pultenaea largiflorens

Swainsona burkittii

@*S. murrayana*

! %*S. reticulata*

[*S. oroboides* subsp. *reticulata*]

S. phacoides

@*S. plagiotropis*

S. procumbens

%*S. sericea*

[*S. oroboides* subsp. *sericea*]

S. swainsonioides

a

a

a

ae

a

a

ae

a

a

abc

ab

a

ad

a

a

a

ae

a

b

ab

a

ae

a

ab

a

ae

a

a

ab

Templetonia egena
**Trifolium angustifolium*
**T. anvense*
**T. campestre*
**T. cernuum*
**T. dubium*
**T. glomeratum*
**T. repens*
**T. striatum*
**T. subterraneum*
**T. tomentosum*
**Vicia hirsuta*
**V. monantha* subsp. *triflora*
**V. sativa* subsp. *sativa*

1

25 29
25

18

a
ae
ae
ae
e
abce
e

abce
ae
ab
ae

Fabaceae-Mimosoideae

Acacia acinacea
A. aneura
A. brachybotrya
A. colletioides
A. dealbata
A. deanei
A. decora
**A. farnesiana*
A. hakeoides
A. homalophylla
A. implexa
A. ligulata
A. lineata
A. loderi
A. melvillei
A. montana
A. oswaldii
A. pendula
%*A. pycnantha*
A. rigens
A. salicina
A. stenophylla
A. victoriae
A. wilhelmiana

1

16 24
16 24

3d

1

16 24 28
16 17
4 16 27

26

a

3d

11

16 17 24 28
16 17 25 27 28

26

a

1

2 16 24
2 16
2
4 16

1

3d
3b 3d

a

Botanical Name	Community		Other Records		
	Forest	Woodland	Mallee	Shrubland	Grassland
Frankeniaceae					
<i>Frankenia connata</i>					
<i>F. crispa</i>				11 21	b
<i>F. latior</i>					a
<i>F. serpyllifolia</i>					b
Fumariaceae					
* <i>Fumaria bastardii</i>					a
* <i>F. capreolata</i> subsp. <i>capreolata</i>					ae
* <i>F. densiflora</i>					a
* <i>F. muralis</i> subsp. <i>muralis</i>					ae
Gentianaceae					
<i>Gentaurium spicatum</i>					abc
* <i>C. tenuiflorum</i>					b
* <i>Cicendia quadrangularis</i>					a
<i>Sebaea ovata</i>					a
Geraniaceae					
* <i>Erodium botrys</i>		25			
* <i>E. brachycarpum</i>					
* <i>E. cicutarium</i>		2 24 25			
<i>E. crinitum</i>	1	2 4 16 25 28 29	3b	8 11 19 21 11 12 18 21	a 26 13 26
<i>E. cynogorum</i> subsp. <i>glandulosum</i>					
* <i>E. malacoides</i>				21	b
* <i>E. moschatum</i>		2 25		11 19 21	
<i>Geranium retrorsum</i>					ae
<i>G. solanderi</i> var. <i>solanderi</i>	1			21	26
Goodeniaceae					
<i>Goodenia cycloptera</i>					
<i>G. fascicularis</i>		25		11	b
<i>G. glauca</i>					
<i>G. gracilis</i>				11	acde
<i>G. heteromera</i>					ab

<i>G. pinnatifida</i>	4 16 25 29	21	a
<i>G. pusilliflora</i>	4 16 25 29	8 11 21	
<i>G. subintegra</i>			
<i>Velleia paradoxa</i>	4 29		
Haloragaceae			
<i>Halragis aspera</i>	2		
<i>H. glauca</i>	25		ab
<i>H. heterophylla</i>			ade
<i>Myriophyllum crispatum</i>			ade
<i>M. verrucosum</i>			
Lamiaceae			
<i>Ajuga australis</i>			a
<i>*Lamium amplexicaule</i>			ae
<i>*Marrubium vulgare</i>	2 24 25 27	26	
<i>Mentha australis</i>	2		
<i>M. diemenica</i>			a
<i>*M. pulegium</i>			a
<i>M. satureoides</i>			a
<i>*Salvia reflexa</i>			a
<i>*S. verbenaca</i>			a
<i>*Stachys anvensis</i>			ad
<i>Teucrium racemosum</i>	2 27 28		
Linaceae			
<i>Linum marginale</i>			ab
<i>*L. usitatissimum</i>			a
Lobeliaceae			
<i>Isotoma fluviatilis</i>			a
<i>!Lobelia pratioides</i>			e
<i>Pratia concolor</i>			d
<i>P. darlingensis</i>			a
	2 25	23	
Loranthaceae			
<i>Amyema linophyllum</i> subsp. <i>orientale</i>			ae
<i>A. miquelii</i>			ae
<i>A. miraculosum</i> subsp. <i>boormanii</i>	16 28		

Botanical Name	Community		Other Records			
	Forest	Woodland	Mallee	Shrubland	Grassland	
Loranthaceae (cont'd)						
<i>Amyema linophyllum. pendulum</i>	1					
<i>A. preissii</i>		2 16				
<i>A. quandang</i> var. <i>quandang</i>		25 28				
<i>Lysiana exocarpi</i> subsp. <i>exocarpi</i>		2 16				
# <i>L. exocarpi</i> subsp. <i>tenuis</i>			3d			
Lythraceae						
<i>Ammannia multiflora</i>						a
<i>Lythrum hyssopifolia</i>		28				a
<i>L. salicaria</i>						
Malvaceae						
<i>Abutilon halophilum</i>		27		11		c
<i>A. otocarpum</i>						a
<i>A. theophrasti</i>						b
<i>Hibiscus brachysiphonius</i>						ac
<i>H. trionum</i>						
<i>Lavatera plebeia</i>		27			26	
* <i>Malva parviflora</i>	1	25 27		11 12 21	13 26	
<i>Malvastrum americanum</i>						b
<i>Sida ammophila</i>		2 27		11	26	
<i>S. corrugata</i>		2 16 25 27 28 29		8.8p 11 19 21	26	
<i>S. cunninghamii</i>		4 16 29				
<i>S. fibulifera</i>	1					
<i>S. intricata</i>		25 27		21	26	a
<i>S. subspicata</i>						
<i>S. trichopoda</i>	1	2 16 25 27		11 21	26	
Martyniaceae						
* <i>Ibicella lutea</i>						a
* <i>Proboscidea louisianica</i>						a
Menyanthaceae						
<i>Nymphoides crenata</i>						ade

Botanical Name	Community		Other Records				
	Forest		Woodland	Mallee	Shrubland	Grassland	
Oleaceae							
<i>Jasminum lineare</i>			16				
Onagraceae							
<i>Epilobium billardierianum</i> subsp. <i>cinereum</i>						ace	
<i>E. hirtigerum</i>						de	
* <i>Ludwigia peploides</i> subsp. <i>montevidensis</i>						d	
* <i>Oenothera affinis</i>						a	
* <i>O. stricta</i> subsp. <i>stricta</i>						a	
Oxalidaceae							
<i>Oxalis corniculata</i> s.lat.						bc	
<i>O. perennans</i>	1		2 16 25 27 28		8 11 12 18 19 21	13 26	
* <i>O. pes-caprae</i>			24				
Papaveraceae							
* <i>Argemone ochroleuca</i> subsp. <i>ochroleuca</i>						a	
* <i>Papaver hybridum</i>					8		
* <i>P. somniferum</i> subsp. <i>setigerum</i>						a	
Pittosporaceae							
<i>Bursaria spinosa</i>			24				
<i>Pittosporum phylliraeoides</i>			4 16 27 29	3d			
Plantaginaceae							
<i>Plantago cunninghamii</i>					11 21		
* <i>P. coronopus</i> subsp. <i>commutata</i>						a	
<i>P. debilis</i>					8		
<i>P. drummondii</i>							
<i>P. gaudichaudii</i>			25			a	
* <i>P. lanceolata</i>						ae	
<i>P. turritera</i>						abc	
<i>P. varia</i>						a	
Plumbaginaceae							
* <i>Limonium sinuatum</i>						a	

Polygonaceae

* <i>Acetosa vesicaria</i>					a
* <i>Acetosella vulgaris</i>					a
* <i>Emex australis</i>					a
<i>Muehlenbeckia florulenta</i>	1	2 25	18	13	
% <i>M. diclina</i>					
<i>M. horrida</i>					a
<i>Persicaria decipiens</i>					acd
<i>P. hydropiper</i>				23	ade
<i>P. lapathifolia</i>					a
<i>P. orientalis</i>					a
<i>P. prostrata</i>					ad
* <i>Polygonum arenastrum</i>					ade
* <i>P. aviculare</i>		28			a
<i>P. decipiens</i>		2			ade
<i>P. plebeium</i>					a
<i>Rumex bidens</i>					
<i>R. brownii</i>	1		18 21		d
* <i>R. crispus</i>		2			abe
<i>R. crystallinus</i>					ac
<i>R. dumosus</i>					a
* <i>R. pulcher</i> subsp. <i>pulcher</i>	1	2 25 27 28	11 12 18 21	13 26	
<i>R. tenax</i>					

Portulacaceae

<i>Calandrinia balonensis</i>					b
<i>C. calypttrata</i>					e
<i>C. eremaea</i>		25	11		a
* <i>C. menziesii</i>					c
<i>C. pumila</i>					ac
% <i>C. volubilis</i>					
<i>Portulaca oleracea</i>		27		26	

Primulaceae

* <i>Anagallis arvensis</i>		25 28 29			a
-----------------------------	--	----------	--	--	---

Proteaceae

<i>Banksia marginata</i>		16 24 27	8		
<i>Hakea leucoptera</i>		16 27 28	8	26	
<i>H. tephrosperma</i>					

Botanical Name	Community		Woodland	Mallee	Shrubland	Grassland	Other Records
	Forest						
Ranunculaceae							
<i>Clematis microphylla</i> var. <i>microphylla</i>			16				
* <i>Myosurus minimus</i> var. <i>australis</i>	1						ade
<i>Ranunculus inundatus</i>							ade
<i>R. lappaceus</i>							a
* <i>R. muricatus</i>							
<i>R. pentandrus</i> var. <i>platycarpus</i>	1		2 25		11 18 19		
<i>R. pumilio</i> var. <i>politus</i>			25				
<i>R. pumilio</i> var. <i>pumilio</i>	1						
* <i>R. sceleratus</i>						23	ade
<i>R. sessiliflorus</i> var. <i>sessiliflorus</i>							e
<i>R. undosus</i>							ade
Resedaceae							
* <i>Reseda luteola</i>							a
Rosaceae							
<i>Acaena novae-zelandiae</i>							a
<i>Aphanes australiana</i>							a
* <i>Rosa canina</i>							a
* <i>R. rubiginosa</i>							ae
* <i>Sanguisorba minor</i> subsp. <i>muricata</i>							a
Rubiaceae							
<i>Asperula conferta</i>			25				
<i>A. cunninghamii</i>							b
<i>A. gemella</i>			25		18		
* <i>Galium aparine</i>							ae
* <i>G. murale</i>							a
Rutaceae							
<i>Flindersia maculosa</i>			4				
<i>Geijera parviflora</i>			4 16 28 29	3d			

Salicaceae**Salix babylonica*

e

Santalaceae*Exocarpos apyllus*

19

E. cupressiformis

a

E. strictus

1

Santalum acuminatum

2 16

S. lanceolatum

16

3d

Sapindaceae*Alectryon oleifolius* subsp. *canescens*

8 8p 21

A. oleifolius subsp. *elongatus*

3d

Dodonaea bursariifolia

16 27

D. lobulata

29

D. viscosa subsp. *angustissima*

3b 3d

D. viscosa subsp. *cuneata*

a

Scrophulariaceae*Glossostigma diandrum*

a

Gratiola pedunculata

ad

**G. pubescens*

a

**Kickxia sieberi*

a

Limosella australis

18

L. curdieana

25

Mimulus gracilis

18

M. prostratus

a

**Parentucellia latifolia*

25

Peplidium foecundum

18

Stemodia florulenta

a

[*Morgania floribunda*]*S. glabella*

a

[*Morgania glabra*]**Verbasicum thapsus* subsp. *thapsus*

a

**V. virgatum*

a

**Veronica arvensis*

a

**V. catenata*

b

V. pleibei

a

**V. peregrina*

a

25

Botanical Name	Community			Other Records		
	Forest	Woodland	Mallee	Shrubland	Grassland	
Solanaceae						
* <i>Datura ferox</i>						a
<i>D. inoxia</i>						a
* <i>D. stramonium</i>						a
* <i>D. wrightii</i>						a
<i>Lycium australe</i>						b
* <i>L. ferocissimum</i>	1	2 16 25 27 28		8 11 18 19 21 18	26	
* <i>Nicotiana glauca</i>						
<i>N. goodspeedii</i>						
<i>N. simulans</i>		29				b
<i>N. velutina</i>						
* <i>Solanum elaeagnifolium</i>						b
<i>S. ellipticum</i>						ab
<i>S. esuriale</i>	1	2 16 25 27 28		8 11 12 18 21	13 26	a
* <i>S. linnaeanum</i>						
* <i>S. nigrum</i>	1	2 28		18		a
* <i>S. pseudocapsicum</i>						
<i>S. rostratum</i>						a
<i>S. simile</i>						a
* <i>S. triflorum</i>						a
Stackhousiaceae						
<i>Stackhousia monogyna</i>						a
Sterculiaceae						
<i>Brachychiton populneus</i> subsp. <i>trilobus</i>		29				
Stylidiaceae						
<i>Levenhookia dubia</i>						a
Thymelaeaceae						
<i>Pimelea curviflora</i>						a
<i>P. microcephala</i> subsp. <i>microcephala</i>						a
<i>P. trichostachya</i>						b
<i>P. stricta</i>						a

Urticaceae <i>Parietaria debilis</i> <i>Urtica incisa</i> * <i>U. urens</i>	27 29	ac abcde
Verbenaceae * <i>Phyla nodiflora</i> * <i>Verbena bonariensis</i> * <i>V. officinalis</i> * <i>V. supina</i>	2 28	ae ab
Violaceae <i>Viola betonicifolia</i>		a
Zygophyllaceae * <i>Tribulus terrestris</i> <i>Zygophyllum ammophilum</i> <i>Z. apiculatum</i> <i>Z. glaucum</i> <i>Z. iodocarpum</i> <i>Z. ovatum</i>	2 27 28	a b
ANGIOSPERMS-MONOCOTYLEDONS		
Alismataceae <i>Damasonium minus</i> * <i>Sagittaria graminea</i> var. <i>platyphylla</i> * <i>S. montevidensis</i> * <i>S. sagittifolia</i>	2	a a a
Alliaceae * <i>Allium triquetrum</i> * <i>Nothoscordum borbonicum</i>		a a
Amaryllidaceae <i>Calostemma purpureum</i> <i>Crinum flaccidum</i>	1	ab

Botanical Name	Community			Other Records		
	Forest	Woodland	Mallee	Shrubland	Grassland	
Anthericaceae						
<i>Arthropodium milleflorum</i>						
<i>A. minus</i>		29				a
<i>Dichopogon fimbriatus</i>						a
<i>Thysanotus baueri</i>						bcd
<i>T. patersonii</i>		29				b
<i>T. tuberosus</i>						a
<i>Tricoryne elatior</i>						
Asparagaceae						
* <i>Asparagus officinalis</i>						ae
* <i>Myrsiphyllum asparagoides</i> [* <i>Asparagus asparagoides</i>]						a
Asphodelaceae						
* <i>Asphodelus fistulosus</i>		25				a
<i>Bulbine alata</i>		25 29				b
<i>B. bulbosa</i>						
<i>B. semibarbata</i>				8		
Colchicaceae						
<i>Wurmbea dioica</i> subsp. <i>dioica</i>		25				
Cyperaceae						
<i>Bolboschoenus fluviatilis</i> [<i>Scirpus fluviatilis</i>]						a
<i>Carex appressa</i>	1					
<i>C. bichenoviana</i>						a
<i>C. inversa</i>						a
<i>C. tereticaulis</i>		25				a
<i>Cyperus bifax</i>						a
<i>C. concinnus</i>						a
<i>C. difformis</i>						ae
* <i>C. eragrostis</i>						ae
<i>C. exaltatus</i>						e
<i>C. gunnii</i>						

<i>C. gymnocaulos</i>			23	ade
<i>C. pygmaeus</i>				ae
<i>C. victoriensis</i>				a
<i>Eleocharis acuta</i>			23	d
@ <i>E. obicis</i>			13	b
<i>E. pallens</i>			13 26	
<i>E. plana</i>				b
<i>E. pusilla</i>				ade
<i>E. sphacelata</i>				ad
<i>Fimbristylis aestivalis</i>			18	a
<i>F. dichotoma</i>			18	ab
<i>F. velata</i>			12	a
<i>Isolepis australiensis</i>				a
[<i>Scirpus australiensis</i>]				
<i>I. congrua</i>				a
[<i>Scirpus congruus</i>]				
<i>I. hookeriana</i>				a
[<i>Scirpus hookerianus</i>]				
* <i>I. hystrix</i>				a
[* <i>Scirpus hystrix</i>]				
<i>I. victoriensis</i>				a
[<i>Scirpus victoriensis</i>]				
<i>Lipocarpus microcephala</i>				a
<i>Schoenus apogon</i>				a
Eriocaulaceae				
@ <i>Eriocaulon australasicum</i>				a
Hydatellaceae				
<i>Trithuria submersa</i>				a
Hydrocharitaceae				
* <i>Egeria densa</i>				a
* <i>Elodea canadensis</i>				a
<i>Hydrilla verticillata</i>				a
<i>Ottelia ovalifolia</i>				a
<i>Vallisneria spiralis</i>			23	ad
Hypoxidaceae				
<i>Hypoxis glabella</i> var. <i>glabella</i>				c
<i>H. hygrometrica</i>				

Botanical Name	Community		Other Records	
	Forest	Woodland	Shrubland	Grassland
Iridaceae				
* <i>Gynandriris setifolia</i>				a
* <i>Homeria flaccida</i>				a
* <i>Romulea flava</i>				a
* <i>R. minutiflora</i>		25		
* <i>R. rosea</i> var. <i>australis</i>		25		
Juncaceae				
* <i>Juncus acutus</i>				ae
<i>J. amabilis</i>				ae
<i>J. aridicola</i>	1			13
* <i>J. articulatus</i>				23
<i>J. bufonius</i>				ade
* <i>J. capitatus</i>				abc
<i>J. flavidus</i>				a
<i>J. holoschoenus</i>		25	12 18 21	d
<i>J. homalocalis</i>				a
<i>J. ingens</i>				a
<i>J. pallidus</i>	1			a
<i>J. radula</i>				
<i>J. semisolidus</i>		25	11 18 21	
<i>J. subsecundus</i>			18	a
<i>J. usitatus</i>				a
Juncaginaceae				
<i>Triglochin calcitrapa</i>				ab
<i>T. hexagona</i>				a
<i>T. procera</i>				ade
<i>T. turrifera</i>				a
Lemnaceae				
<i>Spirodela pusilla</i>				a
Lomandraceae				
<i>Lomandra effusa</i>				

L. filiformis subsp. *coriacea*
L. leucocephala subsp. *robusta*
L. multiflora

a
a
a

Najadaceae

Najas marina
N. tenuifolia

a
a

Orchidaceae

Caladenia carnea
C. dilatata var. *dilatata*
Diuris pedunculata
Microtis uniflora
Prasophyllum fuscum
P. patens
Pterostylis mutica

a
a
a
a
a
a
a

Phormiaceae

Dianella longifolia

abe

Poaceae

Agrostis avenacea
**Aira cupaniana*
**Alopecurus geniculatus*
Amphibromus neesii
A. nervosus
A. whitei
Aristida calycina var. *praealta*
A. behriana
A. jerichoensis subsp. *subspinulifera*
Astrebla lappacea
A. pectinata
**Avena barbata*
**A. fatua*
**A. sativa*
Bothriochloa macra
Brachiaria milliiformis
**Briza maxima*
**B. minor*

1
2 16 27
25
2
18
27
11 19
2 16 25 27 28
3d
25
8 11 19 21
18
11 19
8 8p 11 12 18 19 21 22 26
11
e

ab
ce
a
a
a
a
b
e
a
b
a

Botanical Name	Community			Other Records		
	Forest	Woodland	Mallee	Shrubland	Grassland	
Poaceae (cont'd)						
<i>Bromus alopecuroides</i>						
<i>B. arenarius</i>				11	26	a
* <i>B. catharticus</i>						ace
[* <i>B. unioides</i>]						
* <i>B. diandrus</i>				11 21 22		
* <i>B. hordeaceus</i>						
* <i>B. madritensis</i>		2 4 16 25 27		11 21 22	26	a
* <i>B. molliformis</i>				11		
* <i>B. rubens</i>				21		
* <i>Cenchrus incertus</i>						
* <i>C. longispinus</i>						a
* <i>Chloris gayana</i>						a
<i>C. truncata</i>		2 27		11 21 22	26	a
<i>C. ventricosa</i>						
<i>Cynodon dactylon</i>		28				
<i>Dactyloctenium radulans</i>						
<i>Danthonia auriculata</i>						
<i>D. caespitosa</i>	1	2 4 16 24 25 27 28	3d	8 8p 11 12 18 19 21 22 13 26		ac ac
<i>D. duttoniana</i>						
<i>D. eriantha</i>						
<i>D. linkii</i> var. <i>fulva</i>				21	26	ae
<i>D. setacea</i>		25				
<i>Deyeuxia quadriseta</i>						ae
<i>Dichelachne micrantha</i>						a
<i>Digitaria ammophila</i>						ae
<i>D. brownii</i>						a
* <i>D. ciliaris</i>						a
<i>D. coenicola</i>						a
<i>D. divaricatissima</i>						ab
* <i>D. sanguinalis</i>						ab
<i>Diplachne fusca</i>						a
<i>D. muelleri</i>						abc
<i>Echinochloa colona</i>						b
* <i>E. crus-galli</i>				11		ae
* <i>E. microstachya</i>						a

* <i>E. oryzoides</i>						a
* <i>Ehrharta calycina</i>						a
* <i>E. longiflora</i>						ae
* <i>Eleusine tristachya</i>						a
<i>Elymus scaber</i>						abe
[<i>Agropyron scabrum</i>]						
* <i>Elytrigia repens</i>		2 27				e
<i>Enneapogon avenaceus</i>		27				
<i>E. nigricans</i>						
<i>E. polyphyllus</i>						
<i>Enteropogon acicularis</i>	1	2 16 25 27 28		8 18 21		a
<i>Eragrostis australasica</i>	1	2 25 28		8 11 12 18 19 21	26	13 26
<i>E. brownii</i>					26	
* <i>E. cilianensis</i>		16 27				a
* <i>E. curvula</i>						
<i>E. desertorum</i>						a
<i>E. dielsii</i>						a
<i>E. elongata</i>				8p		
<i>E. eriopoda</i>						ae
<i>E. lacunaria</i>		2 16				ab
<i>E. molybdea</i>		25		8		c
<i>E. parviflora</i>						
* <i>E. minor</i>				21		a
<i>E. setifolia</i>						
<i>Eriochloa australiensis</i>						
<i>E. crebra</i>						ab
<i>E. pseudoacrotricha</i>						ac
<i>Eulalia fulva</i>						abc
<i>Glyceria australis</i>						a
* <i>G. maxima</i>						a
* <i>Holcus lanatus</i>						a
<i>Homopholis proluta</i>				8p		a
[<i>Panicum prolatum</i>]						
* <i>H. hystrix</i>		25				
* <i>H. leporinum</i>		16 27		12 19 21		d
* <i>H. marinum</i>	1	2 4 16 17 24 25 28		8 8p 11 12 18 19 21 22 13 23 26		ace
<i>Iseilema membranaceum</i>						a
<i>I. vaginiflorum</i>						b
* <i>Lamarckia aurea</i>		25		8 11		

Botanical Name	Community		Mallee	Shrubland	Grassland	Other Records
	Forest	Woodland				
Poaceae (cont'd)						
<i>Leptochloa digitata</i>						
* <i>Lolium perenne</i>	1	2 16 24 25		19 11 18 19 21 22	26 26	
* <i>L. rigidum</i>						b
* <i>Lophochloa cristata</i>						b
* <i>L. pumila</i>						a
* <i>Oryzopsis miliacea</i>						a
* <i>Panicum capillare</i> var. <i>capillare</i>						a
* <i>P. capillare</i> var. <i>occidentale</i>						a
<i>P. coloratum</i>	1			8 11		
<i>P. decompositum</i>						
<i>P. effusum</i>		27				
* <i>P. gilvum</i>						a
<i>P. queenslandicum</i> var. <i>queenslandicum</i>						b
<i>P. laevinode</i>						abc
* <i>Parapholis incurva</i>						abc
* <i>P. strigosa</i>						ab
<i>Paspalidium constrictum</i>		2 16				
<i>P. jubiflorum</i>	1					
<i>P. distans</i>						d
* <i>Paspalum dilatatum</i>						ae
<i>P. distichum</i>					23	e
* <i>Pennisetum villosum</i>						a
* <i>Pentstachistis airoides</i>						a
<i>Perotis rara</i>						b
* <i>Phalaris aquatica</i>						ab
* <i>P. minor</i>				11 21 11 12 18 19 21		
* <i>P. paradoxa</i>	1	28			13	d
<i>Phragmites australis</i>	1				23	a
* <i>Poa annua</i>						a
* <i>P. bulbosa</i>						
<i>P. fordeana</i>	1	2		11		
<i>P. labillardieri</i>						ae
* <i>P. pratensis</i>						a
<i>P. sieberana</i>						a

**Polypogon monspeliensis*
Pseudoraphis spinescens
Puccinellia stricta
**Rostraria cristata*
**R. pumila*
**Schismus barbatus*
**Setaria geniculata* var. *pauciseta*
**S. verticillata*

Sporobolus actinocladius

S. caroli

S. mitchellii

Stipa aristiglumis

S. bigeniculata

S. blackii

S. drummondii

S. elegantissima

S. metatoris

S. nitida

S. nodosa

S. platychaeta

S. scabra subsp. *falcata*

S. scabra subsp. *scabra*

Stipa sp.

Themeda australis

Tragus australianus

Triodia scariosa

Tripogon liliiformis

Triraphis mollis

**Vulpia bromoides*

**V. myuros*

Pontederiaceae

**Eichhornia crassipes*

Potamogetonaceae

Potamogeton crispus

P. ochreateus

P. pectinatus

P. perfoliatus

P. tricarlinatus

23				ade
				ae
				ac
				ab
				a
				abcde
				a
				a
				b
26	11	25 27		a
				a
				b
				a
	11	25		e
	19			
	8 8p	4 16 25		
	11	2 25		
26	8	16		a
		27		
		24 28		
	12 21			
			3b	a
				abc
				ab
				ab
26	11	25		
	11 21	4 16 25		
				a
23				ad
				a
				a
				a
				ade

Botanical Name	Community		Other Records	
	Forest	Woodland	Mallee	Shrubland
Ruppiaceae				
<i>Ruppia maritima</i>				
<i>R. megacarpa</i>				
Typhaceae				
<i>Typha domingensis</i>	1	2		
<i>T. orientalis</i>				
Zanichelliaceae				
<i>Lepilaena australis</i>				

Manuscript received 14 January 1993
Manuscript accepted 4 May 1993

The distribution, abundance and habitat of *Eucalyptus dunnii* (Myrtaceae) (Dunn's White Gum) in New South Wales

J.S. Benson and T.C. Hager

Abstract

Benson, J.S.¹ and Hager, T.C.² (¹ National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, NSW, Australia 2000; ² New South Wales National Parks and Wildlife Service, P.O. Box, 1967, Hurstville, NSW, Australia 2220) 1993. The distribution and abundance of *Eucalyptus dunnii* (Myrtaceae) Dunn's White Gum in New South Wales. *Cunninghamia* 3(1): 123–145. *Eucalyptus dunnii* is a tall, fast growing forest tree restricted to north-eastern NSW and south-eastern Queensland. It is phylogenetically close to *Eucalyptus angophoroides* which has its closest occurrences 700 km to the south. *E. dunnii* is a nationally listed rare species. In NSW it has a total population estimated to be 82,000 covering 800 hectares, scattered over 10 locations. The largest populations occur on the Koreelah and Tooloom Ranges near Urbenville, while substantial populations are present 140 km to the south on the ranges inland from Coffs Harbour (several small populations are also present in Queensland). Eighty-two per cent of the area containing *E. dunnii* in NSW is located in state forest and six per cent is protected in conservation reserves. *E. dunnii* is confined to rich basaltic or alluvial soils and mostly grows on the margins of rainforest. A consistent suite of associate plant species is present at most locations, varying due to fire frequency or logging history. It seeds in summer, which coincides with the bushfire season in the region. Extensive logging over the last few decades has led to the dominance (86%) of trees with dbh < 0.5 m. Relatively few large, old trees remain. Further conservation reserves are required to protect southern and western populations.

Introduction

Eucalyptus dunnii Maiden (Myrtaceae) is a tall, smooth-barked tree with a recorded maximum height of 50 m (Yabba State Forest) (Forestry Commission of New South Wales 1989a). It has a limited distribution in north-eastern New South Wales and just crosses the border into south-eastern Queensland (Figure 1). *E. dunnii* is currently regarded as a rare species on the national rare or threatened plant list with a conservation status of 3RCa (Briggs and Leigh 1988). This indicates it is distributed over a range exceeding 100 km, is rare but not in danger of extinction and has over 1000 individuals conserved in conservation reserves.

As *E. dunnii* often dominates the forest canopy it has been distinguished as Forest Type No. 51, Dunn's White Gum, on the forest-type maps produced by the Forestry Commission of New South Wales (1989b). Both Benson (1989) and Hager and Benson (1992) also recognise vegetation dominated by *E. dunnii* as a distinct plant community, one of a number of tall open-forest communities occurring on high nutrient soils in the 1100 to 1500 mm rainfall zone in the far north-eastern corner of NSW. Most of these forests have now been cleared for agriculture or logged and most of the remaining unlogged areas are proposed for logging over the next decade.

This paper presents data on the extent of *E. dunnii* on different land tenures; its abundance and size structure at sample sites; its estimated population in 10 geographically distinct locations; and reviews the conservation status of the species. An analysis of the similarities of site floristics is provided.

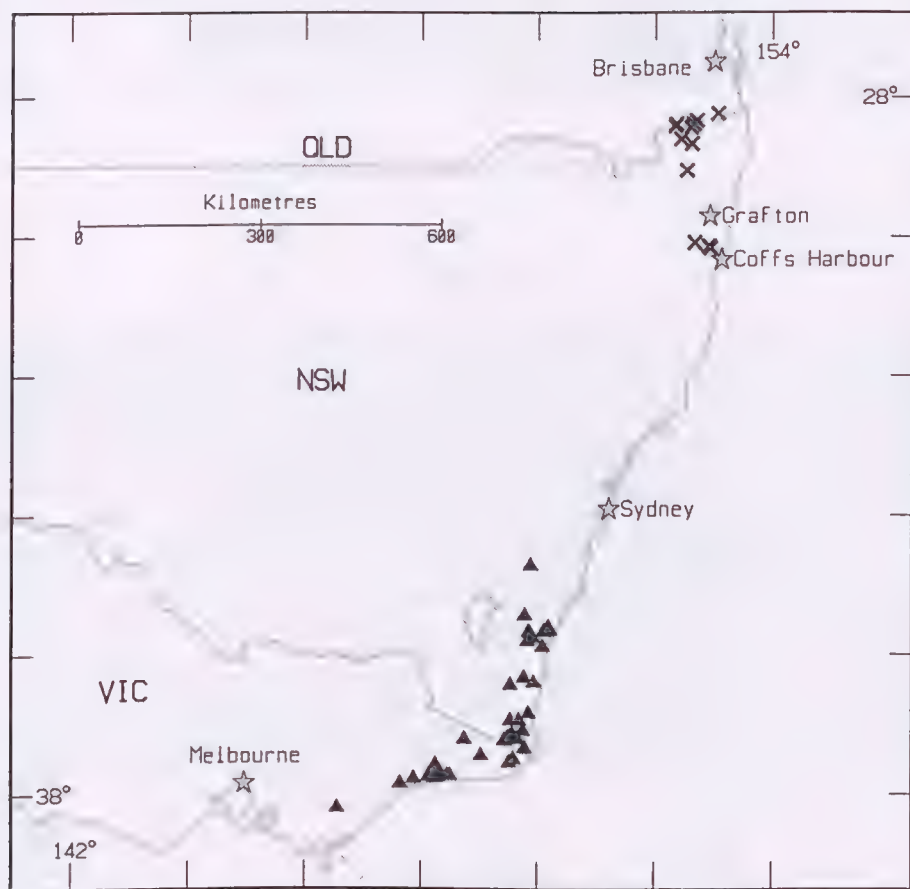


Figure 1. Collections of *Eucalyptus dunnii* (X) and its nearest related species *Eucalyptus angophoroides* (▲) showing their respective geographical ranges in south-eastern Australia. Data from NSW National Herbarium.

Taxonomy

Eucalyptus dunnii has a fibrous, greyish bark on its lower trunk but the bark is smooth above, including the branchlets. Distinguishing morphological features include: juvenile leaves opposite, orbicular to ovate, cordate, dull grey-green (Figure 2); adult leaves narrow-lanceolate, dull green, concolorous; umbellasters 7-flowered; fruit hemispherical or conical or campanulate with exerted valves (Harden 1991).

The occurrence of *E. dunnii* in mixed stands with other smooth-barked eucalypts (gums), such as *E. saligna*, *E. tereticornis* or *E. grandis*, can make field identification of *E. dunnii* difficult. The juvenile leaves and fruit of *E. dunnii* are, however, very distinct from these other associated 'gum' species.

In their phylogenetic classification of *Eucalyptus*, Pryor and Johnson (1971) place *E. dunnii* in Section Maidenaria, Series Viminalis and Subseries Bridgesianinae. They propose *E. angophoroides* (a species occurring 700 km to the south of the southern most occurrences of *E. dunnii*) in south-eastern NSW and north-eastern Victoria (Figure 1),



Figure 2. The distinctive orbicular, juvenile foliage of *Eucalyptus dunnii* is a major distinguishing feature of this species.

as being the closest related species. Both subspecies of *E. bridgesiana* (subsp. *bridgesiana* and subsp. *malacoxylon*), which occur on the tablelands west of the *E. dunnii* occurrences, are also suggested as close relatives to *E. dunnii*. This phylogeny is supported by both the weighted character and unweighted character cladistic analyses undertaken by Chappill (1988). These analyses group *E. dunnii* and 18 other taxa into a *E. globulus* clade within the 'Viminales' clade. The analyses suggest that the closest relative to *E. dunnii* is *E. angophoroides* with *E. bridgesiana* subsp. *bridgesiana* and the threatened Victorian species *E. crenulata* also exhibiting strong affinities. All of these last-mentioned species share the characteristic of crenulate juvenile leaves.

Biology and use of timber

Most of the biological research on *E. dunnii* has been carried out on its growth rates in plantations in Brazil and South Africa, reflecting the importance of the species as a source of pulp for paper production in these countries.

Eucalyptus dunnii is one of the fastest growing eucalypts. Oliveira (1988) reports that it, along with *E. viminalis*, outgrew 31 other species of eucalypts during trials at Tres Barras, Santa Catarina in Brazil at an altitude of 775 m. Impressive growth rates have also been achieved in the Natal midlands, South Africa (Nixon and Hagedorn 1984).

On poorer soils in Brazil, however, *E. grandis* and *E. saligna* were found to be more efficient in using nutrients than *E. dunnii* (Silva H.D. *et al.*, 1983).

Limited studies of stand thinning and stand edges in Brazil (Graca 1987) show that flowering is more abundant with increased availability of light. In Australia, flowering occurs in March and capsules mature over winter. Observations from seed collectors suggest that there is a consistent shedding at the peduncle – pedicel joint, of the four outside capsules before they reach maturity thereby leaving three capsules in the umbellaster (C. Gardiner pers. comm.). Little is known about pollination in the species.

Oliveira (1988) notes that *Eucalyptus dunnii* produces a low quantity of seed in Brazilian plantations thus slowing down some planting programs. Similarly, it is generally a low and unreliable seeder in Australia (Oliveira 1988 and C. Gardiner pers. comm.). Because of its value in the development of overseas plantations, there has been a high demand for *E. dunnii* seed from Australia (valued at A\$1300 kg in 1991, C. Gardiner pers. comm.). The following observations on seed production have been made by C. Gardiner of the CSIRO Australian Seed Tree Centre:

* A heavy crop of seed has been produced in only three of the last 25 years. Two of the three heavy seed crops were observed for the dry years of 1990 and 1991. Little seed was observed in 1992.

* *Eucalyptus dunnii* seems not to be an opportunistic seeder as seed is consistently shed over the summer months before the next flowering begins.

* Seed production is not uniform between populations. While one population may be bearing seed, another may not.

In Australia, the foliage of *E. dunnii* is prone to insect attack, particularly by members of the Psyllidae (lerps). Heavy infestations have been observed to cause death in trees (C. Gardiner pers. comm.) The relative attractiveness of *E. dunnii* to insect attack compared to *E. grandis* has led to it being planted as an insect lure on the edge of *E. grandis* plantations (A. Floyd pers. comm.).

Research on the resistance to termite (*Macrotermes natalensis*) attack (South African Institute for Commercial Forestry Research 1988) ranked *E. dunnii* as being more resistant than all other species of *Eucalyptus* tested. Little is known about its resistance to Australian termite species.

In contrast to its success in pulp production overseas (and use as veneer timber in Australia), Australian foresters and timber companies consider the saw-log timber derived from *E. dunnii* is low in quality, compared to species such as *E. saligna* (Sydney Blue Gum). It has a tendency to warp and shrink during the drying process (E. Chiswell pers. comm., M. Combe pers. comm.).

Methods

Herbarium records from the National Herbarium of NSW, data from the NSW National Parks and Wildlife Service rare plant database and the Forestry Commission's forest type maps formed the basis for identifying the main locations of *E. dunnii*. The term location used in this paper refers to distinct geographic areas such as a mountain range or a creek catchment. Eight of the 10 locations were sampled by means of quadrat-based sites. A total of 30 sites covering the major habitat types and disturbance histories across the geographical distribution of the species were sampled in April 1991.

At each site two quadrats of different sizes were recorded. As far as possible, quadrats were positioned in the centre of stands of *E. dunnii*. The diameter of the tree trunk at breast height (dbh) of all specimens of *E. dunnii* was measured within a 50 X 50 m quadrat. The dbh measurements were assigned to one of three dbh classes (0–0.5 m, 0.51–1.25 m, >1.26 m).

A 20 X 20 m quadrat was placed within the 50 X 50 m quadrat and its floristic composition recorded. Each vascular plant species was assigned a percentage cover rating, using a modified Braun-Blanquet (1932) scale. A structural classification of the vegetation at each site was described using Walker and Hopkins (1990). This included the recognition of different strata in the vegetation and the dominant species therein. Estimates of the time since the last fire or logging were also recorded. Data on altitude, slope, aspect and substrate/soil were recorded.

Abundance data from the sample sites within each location were averaged and extrapolated to give estimates of present population for each of the eight sampled and two unsampled geographical locations. The dbh data are similarly grouped, but the proportion of trees in each size class are given for each site. Some smaller stands of *E. dunnii* on private land, including narrow bands of trees extending down creeks into drier, non-basalt country, were not sampled, although estimates of numbers at some sites are provided. The extent of *E. dunnii* communities on various tenures of land were estimated using a dot matrix overlay on Forestry Commission vegetation type maps and field checked with the assistance of aerial photographs. Geographic locations, such as the Tooloom Range (which extends for over 40 km north to south), contain several populations of *E. dunnii*.

Because some small, remote or inaccessible populations may have been overlooked during the survey, data on the total extent and total population should be considered to be an under-estimate.

To generate site and floristic classifications, the data were subjected to pattern analysis using the PATN package (Belbin 1989). The data matrix included 201 species. This excluded species that only occurred once in the survey and had a cover rating of 1, which add little to the analysis of patterns. The Bray-Curtis association measure (Bray and Curtis 1957) was used to compare the sites according to similarities in their species composition. This measure of association was used in a 'unweighted paired group arithmetic averaging' (UPGMA) (Sneath and Sokal 1973, Belbin 1989) hierarchical clustering strategy and a dendrogram was generated. The clustering parameter (Beta) was set at -0.1. A list was produced which records presence or absence of species from the major groupings defined in the UPGMA cluster analysis.

Results

Distribution and abundance

In NSW there are approximately 82,000 individuals of *E. dunnii* covering approximately 795 hectares distributed over 10 locations (Table 1) from just north of Moleton in the south (Lat. 30°08'S), to the Queensland–NSW border in the north (Lat. 28°18'S) (Figures 3 and 4).

The major populations of *E. dunnii* occur in the upper Clarence River catchment on the McPherson Range (which forms the border between NSW and Queensland) and the north-south orientated, basalt dominated ranges (Acacia Plateau, Koreelah Range, Tooloom Range and Richmond Range) that radiate from it (Tables 1 and 2, Figure 3). These ranges are eroded features of the Focal Peak Volcano which erupted in the

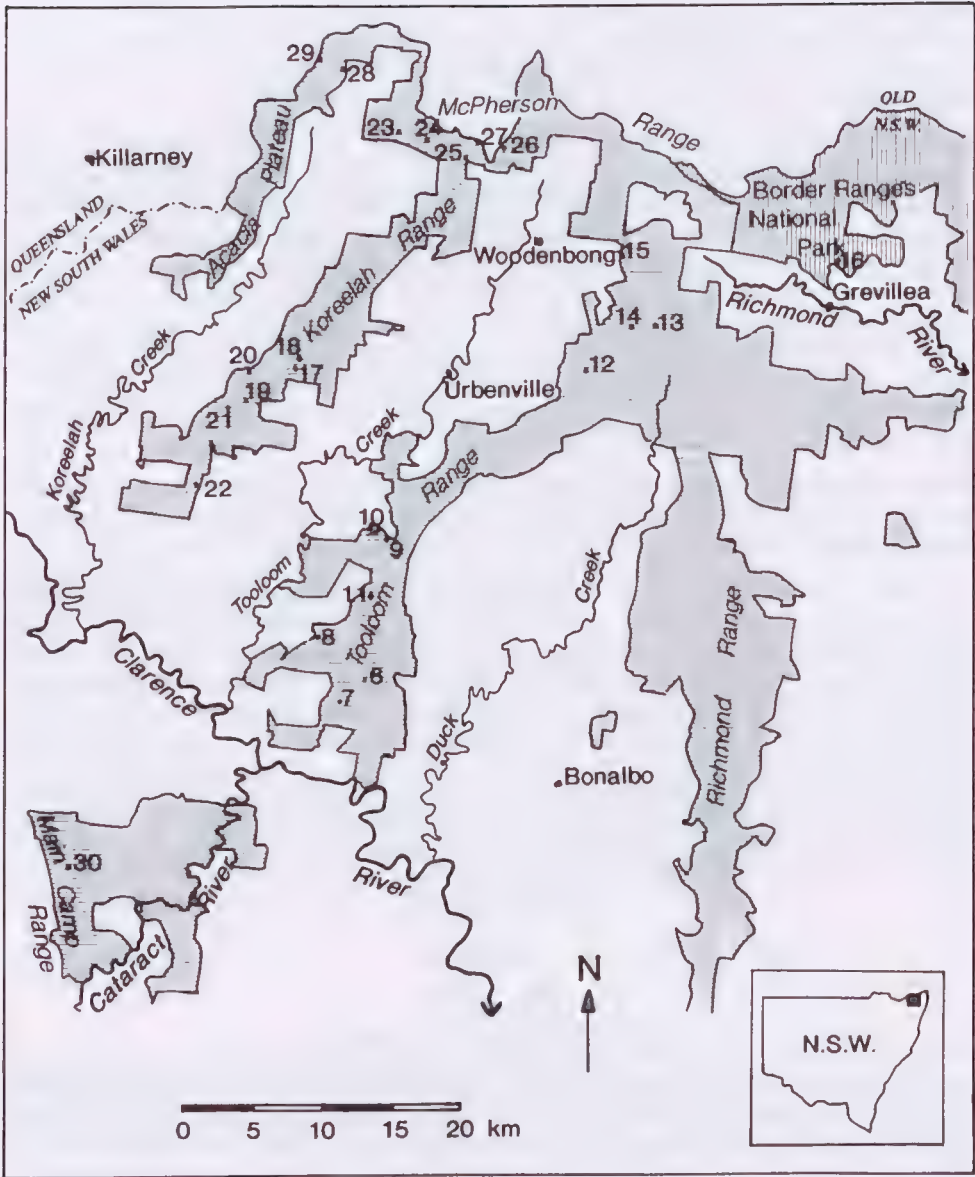


Figure 3. The major populations of *Eucalyptus dunnii* occur on the basalt capped ranges of far north-east NSW. The populations are restricted in size and extent and mainly occur in state forest which is hatched. Sample sites are numbered 6–30.

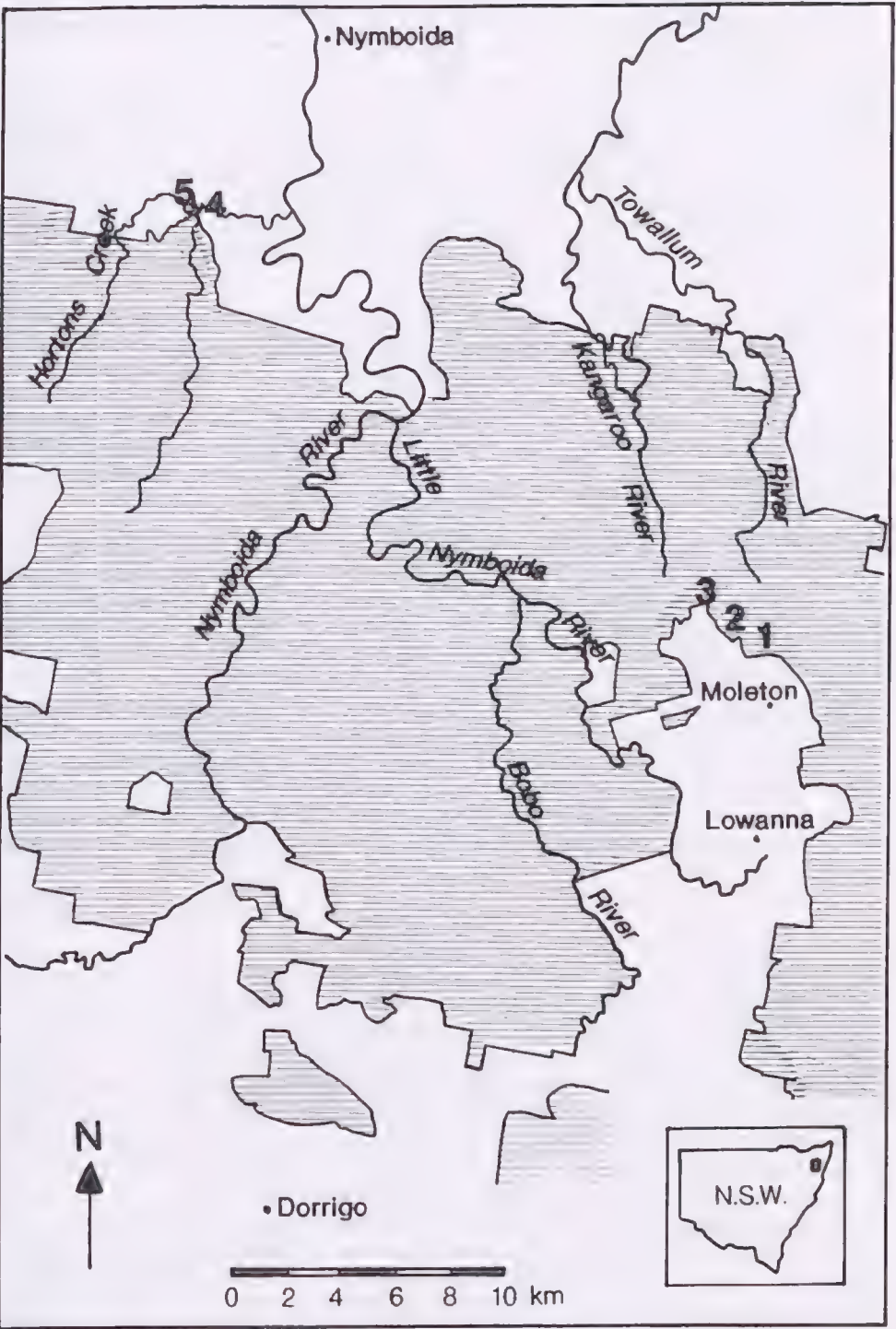


Figure 4. Occurrences of *Eucalyptus dunnii* in the Moleton-Hortons Creek areas inland from Coffs Harbour. Sites are numbered 1-5. Hatched area is state forest.

Tertiary period approximately 25 million years ago. This volcano produced numerous flows of basalt and rhyolite (Stevens 1977, Floyd 1979a, 1979b). Three small populations were recorded in the Richmond River catchment, the eastern-most of which was Terrace Creek, partly inside Border Ranges National Park.

Several populations occur 140 km south of the Focal Peak region (Figure 4). The southernmost locality for the species is at Mole Creek, 4 km north of Moleton which is situated on the coastal ranges 30 km north west of Coffs Harbour. Other populations occur in the adjoining state forests north of Mole Creek. An isolated population is present near the junction of Hortons and Clouds Creeks, 25 km north-west of Moleton and 10 km south of Nymboida. These southern stands of *E. dunnii* also grow on enriched loamy soils but these are derived from a different volcanic source than the rich soils in the Focal Peak region.

A small stand of *E. dunnii* in Gilgurry State Forest north east of Tenterfield represents a western outlier of the species. In common with southern occurrences it is growing on an enriched loamy red soil derived from a small area of residual basalt.

Areas of *E. dunnii* identified on Forestry Commission 1:25 000 scale forest type maps were generally confirmed by the survey. One notable exception is a 70 ha area below Acacia Plateau which was discovered to be *E. saligna*. This area is not accessible by road, which may have restricted ground truthing of the forest typing.

Several isolated populations of *E. dunnii* occur in Queensland near its border with NSW. One stand is on the north-western side of Lamington National Park at Duck Creek, mostly on the private land near O'Reilly's Guest House (W. McDonald pers. comm.). The species is also recorded from Main Range National Park (Briggs and Leigh 1988) in populations contiguous with or close to those of the MacPherson Range. A few hundred individual trees are known from Burnett Creek on the western side of Mount Barney. Clearing for pine plantation has limited the population of *E. dunnii* in Gamubal State Forest, north east of Killarny (P. Young pers. comm.). The most northern location of *E. dunnii*, and the largest stand in Queensland, is located at Spicers Gap on the Cunningham Gap Road approximately 25 km north of the NSW border. In total there would be approximately 300 ha of *E. dunnii* forest in Queensland (P. Young pers. comm.) but little data is available on population or size class structure.

Habitat

Our survey confirmed that *E. dunnii* grows on high nutrient soils. All sample sites were located either on basalt, or on colluvium or alluvium influenced by the presence of basalt upslope or upstream. Surface soils have a neutral pH falling between 6.5 and 7 (C. Gardiner pers. comm.). At its southernmost locations near Moleton, *E. dunnii* grows on red-brown loams derived from residuals of the Towallum Basalt (Dorrigo-Coffs Harbour 1:250 000 geology map). Basalt is also present upslope from its occurrence at Hortons Creek (Floyd 1977). At its northern locations in NSW, *E. dunnii* most often grows on chocolate soils (black earths) derived from basalt (Beckman and Thompson 1977, Floyd 1979a, 1979b). One exception to this is the population in the Peacock Creek valley on the western side of the Richmond Range. This relatively dry site is underlain by sedimentary rocks but there is some basalt enriched alluvium on the creek flats which is where most of the *E. dunnii* grows. The Queensland populations of *E. dunnii* are also confined to basalt and enriched alluvium (P. Young pers. comm.).

Table 1. Occurrence of *Eucalyptus dunnii* communities on various tenures

Location	Tenure	Area (ha)	Number of trees
Kangaroo Creek SF, Moleton	State forest	60	4,900
Clouds/Hortons Creek	Private	23*	3,600
	Crown land	9	2,600
Tooloom Range	State forest	90	9,500
	Private	5	530
Richmond Range	State forest	100	7,700
	Private	1	80
Koreelah Range	State forest	195	22,900
	Flora reserve	35	5,200
	Private	18	2,200
MacPherson Range	State forest	105	10,500
	Flora reserve	9	760
	National Park	5	260
	Private	5	490
Acacia Plateau	State forest	91	6,900
	Private	8	710
Gilgurry	State forest	8	690
Acacia Creek	Private	18	1,600*
Tooloom Creek	Private	5	710*
	Crown land	5	200*
Total (ha)	State forest ^x	649	63,100
	Reserves	49	6,200
	Crown land	14	2,800
	Private	83	9,900
	Total	795	82,000
Total (%)	State forest ^x	81.6	76.9
	Reserves	6.2	7.6
	Crown land	1.8	3.4
	Private	10.4	12.1

^x Excludes flora reserves * Estimate

* Includes 10ha in the process of incorporation into a nature reserve

Note: Number of trees is extrapolated from quadrat data presented in Table 3.

Locations recently disturbed by logging may have the greatest number of trees per ha due to regeneration, but these trees are generally smaller in size than those growing in less recently disturbed locations.

Eucalyptus dunnii grows on a range of aspects but rarely occurs on north-western facing slopes (Table 2). It mainly grows between the altitudes of 400 m and 650 m. The lowest recorded elevation is Terrace Creek in the Border Ranges National Park (210 m) and highest at Mount Clunie Flora Reserve on the McPherson Range (790 m) (Table 2).

Table 2. Site attributes for *Eucalyptus dunnii* occurrences

Location	Site	Easting	Northing	Elev. (m)	Slope (°)	Aspect (°)
Kangaroo Creek SF, Moleton	1	4905	66658	430	10	40
	2	4893	66662	460	2	0
	3	4884	66674	490	0	0
Clouds/Hortons Creek	4	4693	66811	220	2	110
	5	4692	66813	240	6	140
Tooloom Range	6	4495	68283	590	3	20
	7	4476	68267	320	2	10
	8	4462	68317	650	10	232
	9	4508	68383	660	10	170
	10	4500	68388	570	4	162
	11	4501	68342	560	2	274
	12	4651	68496	600	15	356
Richmond Range	13	4669	68528	440	5	270
	14	4682	68531	550	3	232
	15	4683	68583	400	15	36
Koreelah Range	17	4447	68501	420	1	80
	18	4452	68510	430	2	262
	19	4413	68482	630	8	240
	20	4415	68503	760	6	296
	21	4399	68399	610	5	115
	22	4373	68412	540	8	110
MacPherson Range	16	4826	68573	210	5	214
	23	4523	68666	790	20	162
	24	4544	68660	610	10	198
	25	4568	68651	600	12	130
	6	4592	68658	680	35	94
	27	4580	68663	630	4	310
Acacia Plateau	28	4487	6871400	595	0	0
	29	4466	6872300	770	20	96
Gilgurry	30	4281	6816300	670	10	45

Note: AMG eastings and northings include full digit code accurate to 100 m

Table 3. Number and proportion in size classes of *Eucalyptus dunnii* in sites and locations

Location	Site	No. of trees	$\bar{x}$	S.E.	Proportion of trees within DBH classes (metres)		
					0–.5	.51–1.25	1.26–2
Kangaroo Creek SF, Moleton	1	28	20.3	3.2	.68	.25	.07
	2	16			.94	.06	0
	3	17			.59	.29	.12
Clouds/Hortons Creek	4	73	NC	NC	.93	.05	.02
	5	11			.54	.36	.10
Tooloom Range	6	36	26.4	5.2	.97	.03	0
	7	18			.67	.22	.11
	8	36			.94	.06	0
	9	48			.94	.04	.02
	10	18			.67	.22	.11
	11	4			.75	.25	0
	12	25			.96	.04	0
Richmond Range	13	30	19	5.1	1	0	0
	14	18			.94	.06	0
	15	9			.89	.11	0
Koreelah Range	17	31	30.5	7.5	.97	.03	0
	18	12			.92	0	.08
	19	27			.96	.04	0
	20	68			.88	.11	.01
	21	31			.90	.10	0
	22	14			.93	.07	0
MacPherson Range	16	13	22.7	5.3	.77	.15	.08
	23	21			1	0	0
	24	11			1	0	0
	25	33			.88	.12	0
	26	12			.83	.17	0
	27	46			.98	0	.02
Acacia Plateau	28	21	NC	NC	.81	.10	.09
	29	17			.88	.06	.06
Gilgurry	30	30	NC	NC	.74	.22	.04
Acacia Creek	NR						
Tooloom Creek	NR						

NR: not recorded - Acacia Creek and Tooloom Creek locations were not sampled

NC: not calculated

Site: 50 X 50 m quadrat

 $\bar{x}$ (mean) and S.E. (standard error) are provided for locations where sites >2

Population structure

The dbh data (Table 3) reveal that, as of 1991, an overwhelming proportion of the population was composed of small trees. Eighty-six per cent of individuals were in the 0-0.5 m size class compared to 11% in the 0.51-1.25 class and 3% in the >1.25 class. At undisturbed sites with moist understorey species the data suggests that 'old growth' stands may have a ratio of large/medium to small trees in the order of two to three. In contrast most of the current populations occur in recently disturbed sites and contain about nine small trees to each large or medium sized tree.

Very few stands of 'old growth' *E. dunnii* forest were located during the survey. Only five sites contained >30% of trees in the medium to large categories (>0.51 m dbh). These were site 1 near Averies Creek on the border of Kangaroo River State Forest and Bagawa State Forest; site 3 adjacent to Black Mountain Road in Kangaroo River State Forest; site 5 at Hortons Creek; and sites 7 and 10 in Yabbara State Forest on the Tooloom Range.

Regeneration of young trees was observed at all sites, but was most vigorous at sites where there had been recent disturbance (Figure 5), mainly due to logging or clearing over the last 40 years. Under natural conditions mass regeneration would probably



Figure 5. The quick-growing *Eucalyptus dunnii* regenerates well after disturbance although frequent fire may cause a long-term population decline.

occur after hot wildfires or cyclones have disturbed the forest. In this sense *E. dunnii* may behave in a similar fashion as other fire sensitive eucalypts, such as *E. regnans* which forms even aged stands after fire, regenerates on an ashbed and self-thins over time (Ashton 1976). At most locations the natural fire frequency would be expected to be low, since *E. dunnii* grows on moist sites dominated by largely non-flammable species. Large trees (Figure 6) would be common in areas that have not been severely burnt or affected by cyclones for over 150 years (authors' estimate).

Associated plant species

Throughout its range *E. dunnii* occupies an ecotonal zone between drier eucalypt forest and rainforest. The understorey is usually dominated by colonising rainforest species, with the families Myrtaceae, Euphorbiaceae, Lauraceae and Meliaceae prominent.

Eucalyptus saligna, *E. grandis*, *E. microcorys* and *Lophostemon confertus* commonly co-dominate the forest canopy with *E. dunnii*. Several strata are generally present below the canopy of these tall eucalypts. Small to medium-sized trees up to 20 m high make up the next tallest stratum. This is mostly composed of regenerating



Figure 6. Due to logging over recent decades, few mature, large specimens of *Eucalyptus dunnii* remain. This large specimen was located adjacent to Wallaby Creek.

eucalypts but in the vicinity of mature rainforest *Araucaria cunninghamia*, *Diploglottis australis* and *Toona australis* are commonly present. The next layer is most often composed of rainforest trees, tall shrubs and vines including *Neolitsea australiensis*, *Neolitsea dealbata*, *Alectryon subcinereus*, *Cryptocarya rigida*, *Cryptocarya glaucescens*, *Diospyros australis*, *Polyscias elegans*, *Acacia maidenii*, *Rhodamnia rubescens*, *Acmena smithii*, *Croton verreauxii*, *Cordyline petiolaris*, *Cordyline stricta*, *Cissus hypoglauca* and *Cissus antarctica*. A frequently occurring and major weed species is *Lantana camara* which dominates the understorey at sites that have been substantially disturbed by logging, fire or clearing. *Senna floribunda* and *Ageratina adenophora* are other commonly recorded, introduced plants.

On moist sites, estimated by the authors not to have been burnt for more than 30 years, ferns, vines and herbs dominate the forest floor. Common species include the ferns *Adiantum formosum*, *Lastreopsis* spp., *Hypolepis glanduligera*, *Doodia aspera*, *Dennstaedtia davallioides*; vines such as *Derris involuta*, *Palmeria scandens* and *Rubus hillii* and forbs such as *Pollia cristata*, *Alpinia caerulea* and *Alocasia brisbanensis*.

A different array of ground species dominate at drier sites which have been regularly burnt (every 10 years or so) or which have been recently logged. These include *Pteridium esculentum*, *Imperata cylindrica* and *Poa labillardieri*. The herbaceous weed species, *Ageratina adenophora* (crofton weed), was present at heavily disturbed sites.

A total of 239 species of vascular plants were recorded as occurring with *E. dunnii* (Table 4) of which 12 species (5%) were introduced weeds.

Plant community variation

There is a remarkable similarity of floristic composition throughout the range of *E. dunnii* forests in NSW. Observations suggest floristic differences can be explained by disturbance history, particularly recent fire or logging, rather than changes in physiography. This is supported by the UPGMA cluster analysis which grouped the sites into three main floristic groups (groups selected at the 0.8 level of dissimilarity, Figure 7). Group 1 contains sites rich in species, the great majority of which are either pioneer or latter stage rainforest plants. Group 2 contains a combination of rainforest pioneer species and dry sclerophyll species recovering after disturbance within the last two decades. Group 3 contains the two most heavily disturbed sites (11 and 29) both of which had been recently heavily logged and burnt and were species poor.

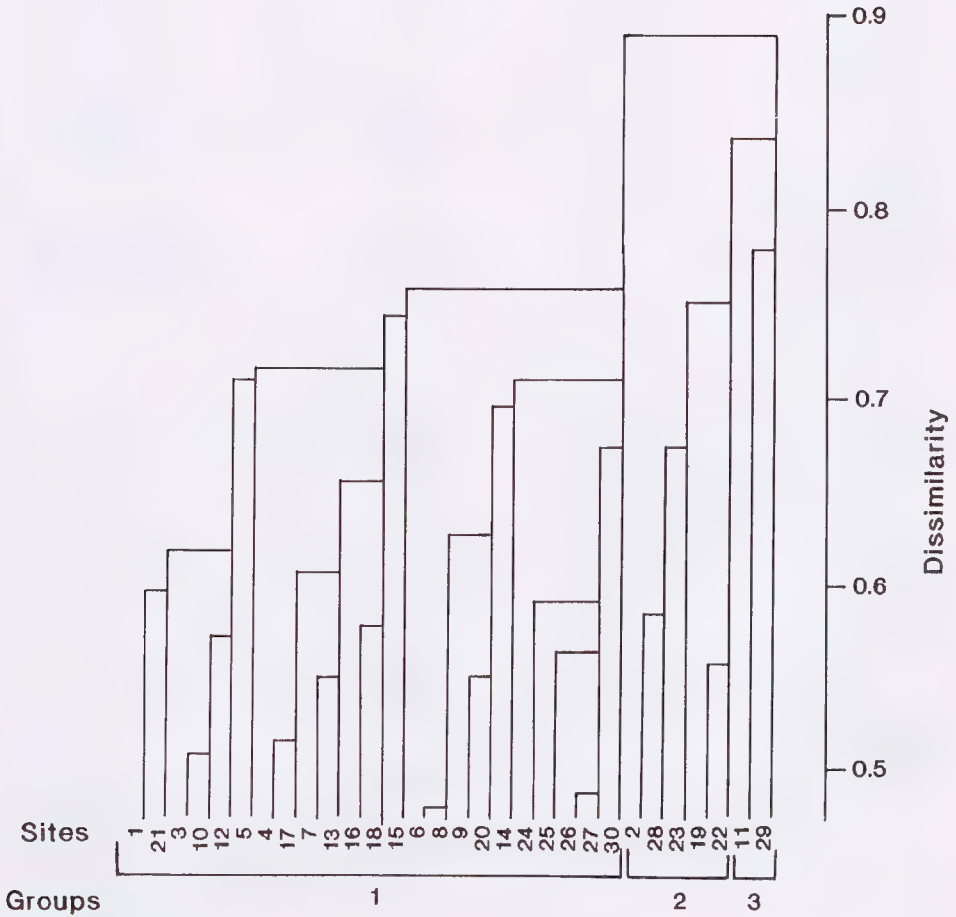


Figure 7. UPGMA generated dendrogram showing the floristic relationships between sites at which *Eucalyptus dunnii* occurs. Brackets show the floristic groupings at the 0.8 level of dissimilarity. This grouping appears to reflect disturbance history.

Table 4. Species occurring in *Eucalyptus dunnii* communities
 (# after species denotes exotic)

UPGMA Group	1	2	3	UPGMA Group	1	2	3
PTERIDOPHYTES							
Adiantaceae				Annonaceae			
<i>Adiantum aethiopicum</i>	*	*		<i>Rauwenhoffia leichhardtii</i>	*		
<i>Adiantum formosum</i>	*	*					
<i>Adiantum hispidulum</i>	*			Apiaceae			
<i>Pellaea falcata</i> var. <i>falcata</i>		*		<i>Hydrocotyle pedicellosa</i>	*		
<i>Pellaea paradoxa</i>	*	*					
Aspidiaceae				Apocynaceae			
<i>Lastreopsis acuminata</i>	*			<i>Alyxia ruscifolia</i>	*	*	
<i>Lastreopsis decomposita</i>	*			<i>Melodinus australis</i>	*		
<i>Lastreopsis microsa</i>	*			<i>Parsonia fulva</i>		*	
<i>Lastreopsis munita</i>	*			<i>Parsonia straminea</i>	*		
<i>Asplenium australasicum</i>	*	*		<i>Parsonia velutina</i>	*		
Blechnaceae				Araceae			
<i>Blechnum cartilagineum</i>	*			<i>Alocasia brisbanensis</i>	*		
<i>Doodia aspera</i>	*	*		<i>Gymnostachys anceps</i>	*	*	
Cyatheaceae				Araliaceae			
<i>Calochlaena dubia</i>	*	*		<i>Cephalalaria cephalobotrys</i>	*		
<i>Cyathea leichhardtiana</i>	*			<i>Polyscias elegans</i>	*	*	*
				<i>Polyscias murrayi</i>	*	*	
Davalliaceae				Arecaceae			
<i>Davallia pyxidata</i>				<i>Archontophoenix</i>	*		
Dennstaedtiaceae				<i>cunninghamiana</i>			
<i>Dennstaedtia davallioides</i>	*			<i>Linospadix monostachya</i>	*		
<i>Hypolepis glandulifera</i>	*			<i>Livistona australis</i>	*		
<i>Peridium esculentum</i>	*	*					
Polypodiaceae				Asclepiadaceae			
<i>Platyterium bifurcatum</i>	*			<i>Araujia hortorum</i> [#]			*
<i>Platyterium superbum</i>	*	*		<i>Gomphocarpus fruticosus</i> [#]		*	
				<i>Marsdenia flavescens</i>	*		
Pteridaceae				<i>Marsdenia suberosa</i>	*		
<i>Pteris tremula</i>	*			<i>Marsdenia velutina</i>	*	*	
GYMNOSPERMS				Asteraceae			
Araucariaceae				<i>Ageratina adenophora</i> [#]	*	*	
<i>Araucaria cunninghamii</i>	*			<i>Bidens pilosa</i> [#]	*	*	*
				<i>Conyza albida</i> [#]			*
ANGIOSPERMS				<i>Ozothamnus rufescens</i>	*		
Agavaceae				<i>Helichrysum rutidolepis</i>		*	
<i>Cordylone petiolaris</i>	*	*		<i>Tagetes minuta</i> [#]	*		
<i>Cordylone stricta</i>	*			Bignoniaceae			
Alangiaceae				<i>Pandorea pandorana</i>	*	*	
<i>Alangium villosum</i>	*			Boraginaceae			
Amaranthaceae				<i>Austrocynoglossum latifolium</i>	*		
<i>Nyssanthus diffusa</i>	*	*		<i>Ehretia acuminata</i>	*	*	
Anacardiaceae				Capparaceae			
<i>Euroschinus falcata</i>	*			<i>Capparis sarmentosa</i>	*		

UPGMA Group 1 2 3

Casuarinaceae

- Allocasuarina torulosa* *
- Casuarina cunninghamiana* *

Celastraceae

- Cassine australis* * *
- Celastrus subspicatus* * *
- Denhamia celastroides* *
- Maytenus bilocularis* *
- Maytenus silvestris* * *

Commelinaceae

- Aneilema acuminatum* *
- Commelina cyanea* *
- Pollia crispata* * * *

Convolvulaceae

- Dichondra repens* *

Cucurbitaceae

- Zehneria cunninghamii* *

Cunoniaceae

- Aphanopetalum resinum* *
- Caldcluvia paniculosa* *

Cyperaceae

- Carex appressa* * *
- Gahnia melanocarpa* * *
- Lepidosperma laterale* *

Dilleniaceae

- Hibbertia scandens* * *

Dioscoreaceae

- Dioscorea transversa* *

Ebenaceae

- Diospyros australis* * *
- Diospyros pentamera* * *

Elaeocarpaceae

- Elaeocarpus obovatus* * *

Epacridaceae

- Acrotriche latifolia* *
- Trochocarpa laurina* *

Euphorbiaceae

- Baloghia inophylla* *
- Breynia oblongifolia* * *
- Bridelia exaltata* *
- Claoxylon australe* * *
- Cleistanthus cunninghamii* *
- Coelebogyne ilicifolia* *
- Croton verreauxii* * * *
- Drypetes australasica* *
- Glochidion perakense* *
- Mallotus philippensis* * *
- Omalanthus populifolius* *

UPGMA Group 1 2 3

Eupomatiaceae

- Eupomatia laurina* * *

Fabaceae

Faboideae

- Austrosteenisia glabristyla* *
- Derris involuta* * *
- Desmodium nemorosum* *
- Glycine clandestina* *
- Goodia lotifolia* *
- Indigofera australis* *
- Kennedia rubicunda* * *
- Swainsona galegifolia* *

Caesalpinoideae

- Senna floribunda* * *

Mimosoideae

- Acacia filicifolia* * * *
- Acacia irrorata* ssp. *irrorata* * *
- Acacia maidenii* * *
- Acacia melanoxylon* * * *

Flacourtiaceae

- Scolopia braunii* *

Icacinaeae

- Pennantia cunninghamii* *

Lamiaceae

- Plectranthus parviflorus* * *

Lauraceae

- Beilschmiedia obtusifolia* *
- Cinnamomum oliveri* *
- Cryptocarya erythroxylon* *
- Cryptocarya glaucescens* * *
- Cryptocarya microneura* * *
- Cryptocarya obovata* *
- Cryptocarya rigida* * *
- Cryptocarya triplinervis* *
- var. *pubens* *
- Endiandra muelleri* *
- Endiandra sieberi* *
- Neolitsea australiensis* * *
- Neolitsea dealbata* *

Liliaceae

- Dianella caerulea* *

Malvaceae

- Abutilon grandifolium* *
- Hibiscus heterophyllus* * *

Meliaceae

- Anthocarpa nitidula* *
- Dysoxylum fraserianum* * *
- Dysoxylum rufum* *
- Melia azedarach* * *
- Synoum glandulosum* * *
- Toona australis* *

Table 4 (cont'd)

UPGMA Group	1	2	3	UPGMA Group	1	2	3
Menispermaceae				Pittosporaceae			
<i>Legnephora moorei</i>	*			<i>Billardiera scandens</i>		*	
<i>Sarcopetalum harveyanum</i>	*	*		<i>Citriobatus pauciflorus</i>	*	*	*
<i>Stephania japonica</i>	*	*	*	<i>Hymenosporum flavum</i>	*		
				<i>Pittosporum revolutum</i>	*	*	
Monimiaceae				<i>Pittosporum rhombifolium</i>	*		
<i>Daphnandra micrantha</i>	*		*	<i>Pittosporum undulatum</i>	*	*	
<i>Doryphora sassafras</i>	*						
<i>Hedycarya angustifolia</i>	*	*		Poaceae			
<i>Palmeria scandens</i>	*			<i>Imperata cylindrica</i>	*	*	*
				<i>Opismenus imbecillis</i>	*	*	
Moraceae				<i>Poa labillardieri</i>		*	
<i>Ficus coronata</i>	*	*		<i>Themeda australis</i>		*	
<i>Ficus watkinsiana</i>	*						
<i>Maclura cochinchinensis</i>	*	*	*	Proteaceae			
<i>Malaisia scandens</i>	*	*		<i>Grevillea robusta</i>	*		
				<i>Persoonia attenuata</i>		*	
Myrsinaceae							
<i>Embelia australiana</i>	*			Ranunculaceae			
<i>Rapanea howittiana</i>	*			<i>Clematis aristata</i>	*		*
<i>Rapanea variabilis</i>	*	*		<i>Clematis glycinoides</i>	*		
Myrtaceae				Rhamnaceae			
<i>Acmena smithii</i>	*		*	<i>Alphitonia excelsa</i>	*		
<i>Angophora subvelutina</i>	*	*					
<i>Austromyrtus bidwillii</i>	*			Rosaceae			
<i>Callistemon salignus</i>	*	*		<i>Rubus hillii</i>	*	*	
<i>Eucalyptus acmenioides</i>	*			<i>Rubus rosifolius</i>	*	*	
<i>Eucalyptus dunnii</i>	*	*	*				
<i>Eucalyptus grandis</i>	*			Rubiaceae			
<i>Eucalyptus maculata</i>	*			<i>Canthium buxifolium</i>		*	
<i>Eucalyptus microcorys</i>	*	*		<i>Hodgkinsonia ovatiflora</i>	*		
<i>Eucalyptus propinqua</i>	*	*		<i>Morinda jasminoides</i>	*		
<i>Eucalyptus saligna</i>	*	*	*	<i>Psychotria daphnoides</i>	*	*	
<i>Eucalyptus siderophloia</i>	*			<i>Psychotria loniceroides</i>	*	*	
<i>Eucalyptus tereticornis</i>		*	*				
<i>Lophostemon confertus</i>	*	*	*	Rutaceae			
<i>Melaleuca bracteata</i>	*			<i>Acronychia oblongifolia</i>	*	*	
<i>Rhodamnia rubescens</i>	*	*		<i>Euodia micrococca</i>	*	*	
<i>Rhodomyrtus psidioides</i>	*			<i>Geijera salicifolia</i>	*	*	
<i>Syncarpia glomulifera</i>		*		<i>Sarcomelicope simplicifolia</i>	*		
<i>Syzygium australe</i>	*			<i>Zanthoxylum brachyacanthum</i>	*		
<i>Syzygium oleosum</i>	*						
<i>Tristaniopsis laurina</i>	*			Santalaceae			
				<i>Santalum obtusifolium</i>		*	
Oleaceae							
<i>Notelaea venosa</i>	*	*		Sapindaceae			
				<i>Alectryon subcinereus</i>	*	*	
Orchidaceae				<i>Arytera divaricata</i>	*		
<i>Calanthe triplicata</i>	*			<i>Cupaniopsis parvifolia</i>	*	*	
				<i>Diploglottis australis</i>	*		
Passifloraceae				<i>Elattostachys nervosa</i>	*		
<i>Passiflora edulis*</i>	*	*		<i>Guioa semiglauc</i>	*	*	
<i>Passiflora foetida*</i>	*			<i>Sarcopteryx stipitata</i>	*		
<i>Passiflora subpeltata*</i>	*						
				Sapotaceae			
Philesiaceae				<i>Planchonella australis</i>	*		
<i>Geitonoplesium cymosum</i>	*	*	*				

UPGMA Group	1	2	3	UPGMA Group	1	2	3
Smilacaceae				Urticaceae			
<i>Ripogonum album</i>	*			<i>Dendrocnide excelsa</i>	*	*	*
<i>Ripogonum discolor</i>	*			<i>Dendrocnide photinophylla</i>	*		
<i>Ripogonum elseyanum</i>	*			<i>Elatostema reticulatum</i>	*		
<i>Smilax australis</i>	*	*	*	<i>Urtica incisa</i>	*		
Solanaceae				Verbenaceae			
<i>Duboisia myoporoides</i>	*			<i>Clerodendrum tomentosum</i>	*	*	
<i>Solanum aviculare</i>	*			<i>Lantana camara</i> *	*		
<i>Solanum campanulatum</i>	*						
<i>Solanum cinereum</i>	*			Vitaceae			
<i>Solanum mauritianum</i> *	*		*	<i>Cayratia clematidea</i>	*		
<i>Solanum stelligerum</i>	*	*		<i>Cissus antarctica</i>	*	*	*
				<i>Cissus hypoglauca</i>	*	*	
Sterculiaceae				<i>Cissus sterculiifolia</i>	*		
<i>Heritiera antinophylla</i>	*			<i>Tetrastigma nitens</i>	*	*	
Symplocaceae				Winteraceae			
<i>Symplocos thwaitesii</i>	*			<i>Tasmannia insipida</i>	*		
Thymelaeaceae				Xanthorrhoeaceae			
<i>Phaleria chermsideana</i>	*			<i>Lomandra longifolia</i>	*	*	
<i>Pimelea ligustrina</i>			*				
<i>Pimelea pauciflora</i>		*		Zingiberaceae			
<i>Wikstroemia indica</i>	*	*		<i>Alpinia caerulea</i>	*		
Ulmaceae							
<i>Aphananthe philippinensis</i>	*						
<i>Trema aspera</i>	*	*					

Conservation

Of the estimated 795 ha of *E. dunnii* forest community in NSW, 87% (693 ha) occurs in state forest. Of this 6% (44 ha) is protected in flora reserves managed by the Forestry Commission. The only sample represented in reserves managed by the NSW National Parks and Wildlife Service is 5 ha in Border Ranges National Park, the understorey of which is engulfed by *Lantana*. Therefore, just over 6% of the area of *E. dunnii* is located in conservation reserves. About 10% (83 ha) is estimated to remain on private land and a small area is located on Crown land (Table 1).

It is estimated that 6200 individuals of *E. dunnii* are conserved in reserves (Table 1). The largest protected population is in Tooloom Scrub Flora Reserve in Beaurty State Forest near Urbenville. Another population is reserved in Mount Clunie Flora Reserve in Koreelah State Forest north of Urbenville. The two major reserved populations in flora reserves managed by the Forestry Commission have been partially logged in the past (Forestry Commission of NSW 1989b). They contain large numbers of post logging saplings.

The recently gazetted Hortons Creek Nature Reserve conserves 10 ha of *Eucalyptus dunnii* containing approximately 540 trees. Small stands are protected in two conservation reserves in Queensland (Main Range and Lamington National Parks).

Discussion

The fact that *E. dunnii* survives in disjunct populations on high nutrient soil raises the question of its origin and history. Silva's (1983) findings that *E. grandis* and *E. saligna* grow better than *E. dunnii* on low fertility soils suggest that *E. dunnii* may be more dependent than these other eucalypts on the presence of rich soil such as that derived from basalt. Consequently, it may have been more common in the geological past but has been restricted by the erosion of much of the original Tertiary basalt, thus reducing the size of its potential habitat. Wallaby Knob near Wallaby Creek on the southern end of the Koreelah Range is one example of residual basalt in a valley now dominated by Jurassic sedimentary rocks (Floyd 1979c). Studies of genetic variation between isolated populations may yield information on the relative levels of differentiation and therefore estimates of the time since the population was more continuous. Alternatively, the disparate populations could have arisen through seed dispersal, although the mechanisms for this are not known.

The survival of *E. dunnii* seedlings in the presence of rainforest species indicates it has a capacity to grow rapidly after disturbance. Seedlings presumably need to gain height quickly to reach available light before they are smothered by broad-leaved rainforest vines and shrubs. It would seem that intermittent disturbance is important for the survival of stands of *E. dunnii*, otherwise it would eventually senesce and be replaced by rainforest, although we did observe seedlings germinating in localised openings (10 m diameter) of the rainforest canopy. There is little documentation on the frequency of disturbance (fire, cyclone) in pre-European times. In protected situations it may have been in the order of hundreds of years based on the size of several species of trees (*E. saligna*, *E. dunnii*, *E. grandis* and *Lophostemon confertus*) in undisturbed sites. While *E. dunnii* appears not to be opportunistic in timing its seed shedding, the fact that this happens during summer coincides with the wildfire and cyclone season. This may be an advantageous adaption to ensure successful recruitment after disturbance.

Threats

Since European settlement the main impacts on the population of *E. dunnii* have been due to clearing of river flats and foothills for grazing stock and logging of remaining forests. We do not have accurate figures on the species' original distribution but it would seem that a number of populations were cleared on alluvial flats at lower altitudes. This supposition is supported by the survival of old trees in the Urbenville Showground, along Tooloom Creek near Woodenbong and along Acacia Creek.

The size class data suggests that most of the populations of *E. dunnii* have been heavily logged over the last forty years. Few old growth stands remain and it appears that there has been a major shift towards smaller trees of younger age, but possibly a larger population.

Logging on a long rotation (say once in 150 years) is unlikely to threaten the species but increased fire frequency associated with post-logging management of the forest or repeated logging on short rotations may do so. If populations are burnt too often (at intervals less than 20 years) young trees, susceptible to even cool fires, may be killed before they reach seed-bearing age. This could lead to a fall in recruitment. Frequent fires also discriminate against fire sensitive rainforest understorey shrubs and trees.

Anecdotal evidence from seed collectors (C. Gardiner pers. comm.) suggests that

large, old trees yield more seed than young ones. This may be related, in part, to the fact that old, tall trees are exposed to maximum light and there is evidence that increased light leads to greater seed production (Graca 1987). Therefore, seed production (and regenerative capacity) could benefit from the protection of remaining old trees in each population. It could also benefit from more medium-sized trees being left to attain full maturity.

Other threats include seed collection, insect attack and weed infestation. Some old trees have been severely pruned by seed collectors. The long-term effects of this activity have not been researched. *Lantana camara* is a major weed in some locations and may inhibit seedling establishment. Its vigour tends to decrease with increased shade that results from regrowth of trees in the middle and upper strata of the vegetation.

Adequacy of conservation

The present population statistics provide a somewhat inflated impression of the species abundance because of the degree of regeneration after recent logging of most stands. It is likely the population will decrease over time due to natural thinning in the stands.

It is estimated that between 5% and 10% of the 795 ha of *E. dunnii* forest remains unlogged, containing a relative high proportion of large, mature trees (derived from Tables 1 and 3). While the species is reasonably well conserved in the northern part of its range, there is very little overall representation of mature forest in these reserves. In the absence of repeated logging or burning this situation could improve over the next century.

Eucalyptus dunnii is not protected at its western-most occurrence in Gilgurry State Forest near Tenterfield. This small but geographically distinct population was heavily logged in 1990. Prior to logging, this stand was one of the last old growth *E. dunnii* forests remaining in NSW. Because *E. dunnii* is regenerating at the site, along with the presence of a good patch of sub-tropical rainforest, it is suggested that the Gilgurry site should be protected in a flora reserve.

The unlogged stand of *E. dunnii* at site 3 adjoining the Black Mountain Road at the southern end of its distribution warrants flora reserve status not only for *E. dunnii* but also for the unusual ridgetop presence of *Toona australis* (Red Cedar). To the east the existing Twelve Sixty Flora Reserve should be extended to protect the *E. dunnii* population near Averys Creek (site 1).

Only part of the *E. dunnii* stand at Hortons Creek is conserved in the Hortons Creek Nature Reserve. Most of the population is downslope and outside the reserve on land adjacent to Cloud's Creek. This area should be added to the nature reserve.

Additional areas of *E. dunnii* could also be protected in Yabbra State Forest which contains significant populations of the species. Also, further populations may be able to be conserved in Queensland where the species is apparently rarer than in NSW.

Based on its population and the likely impact of existing threats, *E. dunnii* is in no immediate danger of extinction. Due to its restricted distribution retention of the 3RCa status on the national rare or threatened list (Briggs and Leigh 1988) appears to be warranted.

Acknowledgements

We wish to thank the Forestry Commission of NSW for granting a research permit to conduct surveys on state forests and in particular Foresters Mr Ernie Chiswell (Coffs Harbour), Mr Michael Combe (Tenterfield) and Mr Mark Carron (Urbenville) for their advice. Botanists of the National Herbarium of NSW assisted with species identification. We are grateful Mr Ken Hill for commenting on the manuscript. Mr Craig Gardiner provided valuable information on seeding and flowering in the species. Ms Judith Scott helped with data analysis and prepared the figures.

References

- Ashton, D.H. (1976) The development of even-aged stands of *Eucalyptus regnans* F. Muell. in central Victoria. *Aust. J. Bot.* 24: 397–414.
- Beckmann, G.G. and Thompson, C.H. (1977) The Soils. In Monroe, R. and Stevens, N.C. (eds). *The Border Ranges. A land use conflict in regional perspective*. Royal Society of Queensland, Brisbane.
- Belbin, L. (1989) *PATN Manuals* CSIRO Wildlife and Ecology, Canberra.
- Benson, J.S. (1989) Establishing priorities for the conservation of rare or threatened plants and plant associations in New South Wales. In M. Hicks and P. Eiser (eds) *The conservation of threatened species and their habitats*. Australian Committee for IUCN, Canberra. Occasional Paper No. 2.
- Braun-Blanquet, J. (1932) *Plant sociology: the study of plant communities* (English translation by G.D. Muller and H.S. Conrad). (McGraw Hill: New York.)
- Bray, J.R. and Curtis, J.T. (1957) An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs* 27: 325–349.
- Briggs, J.D. and Leigh J.H. (1988) *Rare or threatened Australian plants*. Australian National Parks and Wildlife Service, Special Publication no. 14.
- Chappill, J.A. (1988) A systematic study of *Eucalyptus* L'Herit. Informal Subgenus Symphyomytus, Section Maidenaria (Myrtaceae). PhD Thesis, School of Botany, University of Melbourne.
- Floyd, A.G. (1977) Hortons Creek Nature Reserve proposal. Rainforest Report. NSW National Parks and Wildlife Service, Sydney.
- Floyd, A.G. (1979a) McPherson Range (west) – Mount Wilson to Mount Clunie Forest Preserves. Rainforest Report. NSW National Parks and Wildlife Service, Sydney.
- Floyd, A.G. (1979b) The vegetation of the Border Ranges. Rainforest Report. NSW National Parks and Wildlife Service, Sydney.
- Floyd, A.G. (1979c) Wallaby Creek and Beauray State Forest: Rainforest Report. NSW National Parks and Wildlife Service, Sydney.
- Forestry Commission of New South Wales. (1989a) *Forest preservation in State forests of New South Wales, 2nd edition*. Research Note No. 47. Forestry Commission of New South Wales, Sydney.
- Forestry Commission of New South Wales. (1989b) *Forest types in New South Wales*. Research Note No. 17. Forestry Commission of New South Wales, Sydney.
- Graca, M.E.C. (1887) Evaluation of flowering and seed production potential of *Eucalyptus dunnii* in Brazil. *Bulletin of Forest Flora Research* no 14: 1–12. National Centre of Forest Flora Research, Curitiba, Parana, Brazil.
- Hager, T. and Benson, J.S. (1992) Review of the conservation of plant communities in New South Wales. Assessment of the conservation status of forest plant communities in north eastern NSW. Report to the Australian Heritage Commission, Canberra.
- Harden, G.J. (Ed.) (1991) *Flora of New South Wales, Volume 2*. (New South Wales University Press: Kensington.)
- Nixon, K.M. and Hagedorn, S.F. (1984) A *Eucalyptus* species and provenance trial on two sites in the Natal Midlands. In *Report of the Wattle Research Institute*, University of Natal.
- Oliveira, J.G. (1988) *Eucalyptus* tree improvement program at Rigesa. In J.G. Carneiro *et al.* (ed) *Bilateral symposium Brazil-Finland on forestry actualities*, Curitiba, Parana, Brazil.

- Prior, L.D. and Johnson, L.A.S. (1971) *A classification of the eucalypts*. Australian National University, Canberra.
- Silva, H.D., Poggiani, F. and Coelho, L.C. (1983) Nutrient utilization efficiency in five *Eucalyptus* species. *Bulletin of Forest Flora Research* no. 6-7: 1-8. National Centre of Forest Flora Research, Curitiba, Brazil.
- Sneath, P.H.A. and Sokal R.R. (1973) *Numerical taxonomy: the principals and practice of numerical classification*. (W.H. Freeman and Co.: San Francisco.)
- South African Institute of Commercial Forestry Research. (1988) *Annual Report*. South African Institute of Commercial Forestry Research, University of Natal.
- Stevens, N.C. (1977) Geology and landforms. In Monroe, R and Stevens, N.C. (eds). *The Border Ranges. a land use conflict in regional perspective*. Royal Society of Queensland, Brisbane.
- Walker, J. and Hopkins, M.S. (1990) Vegetation. In McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. *Australian soil and land survey field handbook*, 2nd edition. (Inkata Press: Melbourne.)

Manuscript received 22 December 1992

Manuscript accepted 24 March 1993

Prediction of the habitat for *Tetratheca juncea* in the Munmorah area, near Wyong, New South Wales

R.J. Payne

Abstract

Payne, R.J. (c/- Andrews Neil, 207 Albany Street North, Gosford, NSW Australia, 2250) 1993. *Prediction of the habitat for Tetratheca juncea in the Munmorah area, near Wyong, New South Wales*. *Cunninghamia* 3(1): 147–154. *Tetratheca juncea* (Tremandraceae) is a rare plant of the coastal area between Wyong and Bulahdelah. A large population of the species at Munmorah is being reduced because its habitat is being destroyed by infrastructural development. Site conditions have been identified that may be used to locate other populations occurring further north and west of the current survey.

Introduction

Tetratheca juncea Sm. (Tremandraceae) is a species difficult to locate amongst natural vegetation. Its morphological features are such that it is not easily distinguished amongst other shrubs, herbs, grasses and graminoids in most seasons, but is conspicuous when in flower. Although collections have been recorded from the Sydney suburban area, it is now believed to be extinct there (Harden, 1992). Other occurrences are from the Wyong–Bulahdelah area north of Sydney (collections held in the National Herbarium of New South Wales and records of the New South Wales National Parks and Wildlife Service). It is included on the rare or threatened Australian plants list of Briggs and Leigh (1988) with a coding of 3VCi indicating that it is a vulnerable species and is inadequately conserved.

Previous collections provide scant information on the habitat of *Tetratheca juncea*. Residential development around Sydney has eliminated its habitat but a large population has recently been found in the Munmorah area, near Wyong, north of Sydney. The population at Munmorah lies alongside the Pacific Highway and occurs west as far as Point Wolstoncroft on the Triassic Clifton Sub-group geological formation (Uren, 1977). This paper provides details of the habitat of *Tetratheca juncea* and the future conservation needs of the population.

Locations

Tetratheca juncea has been recorded from localities between Sydney and Bulahdelah (Fig. 1). Collections from the Sydney area (e.g., Carlton, Kogarah, Bexley and Undercliff) are early records and the species is now believed to be extinct in those areas (Harden, 1992). Although no habitat details are given, localities suggest the species grew in areas of Hawkesbury Sandstone.

Collections from the Wyong to Bulahdelah area (Fig. 1) are poorly documented in herbarium records. They indicate that the species grows in poor sandy soils around Lake Macquarie but at Bulahdelah grows on a wider range of soils from clays to limestones. At Redhead it has been reported from aeolian sands.

Few of the past records give details of associated vegetation. At Swansea it has been reported in *Angophora costata*-*Eucalyptus haemastoma* forest whilst at Bulahdelah from woodland of *A. costata*-*Allocasuarina littoralis*. On the aeolian sand dunes at Redhead it occurs in *Banksia aemula* heathland.

In the Lake Macquarie area Bartrim and Martin (1986), Kidd (1991) and Winning (1992) have more recently documented specific sites for *Tetratheca juncea* and have given details of vegetation associated with the species. Both Bartrim and Martin (1986) and Winning (1992) describe it as occurring in woodland/forest of *Eucalyptus haemastoma*, *Eucalyptus gummifera* and *Angophora costata* although on one occasion it was recorded in forest of *E. maculata*-*E. paniculata* at Green Point. All of the sites reported occur in relative close proximity to Lake Macquarie with some outlying populations near Mt Sugarloaf to the north west.

Populations in the Munmorah area

Populations of *Tetratheca juncea* were recorded during field investigations in June 1991 in the Munmorah area. A corridor, approximately 5 kilometres long, through natural vegetation on hilltops and valleys between Munmorah and the Wallarah Colliery was examined. Surrounding lands covering a total area of 12 square kilometres including the Munmorah State Recreation Area and sites at Point Wolstoncroft were also examined, specifically on hilltops but not valleys. At least 14 sites revealed populations of *Tetratheca juncea*, although only eight sites are detailed here (Table 1). Both populations and isolated plants were recorded. A population was designated where more than 20 plant clumps could be recorded along a ridge length of 100 metres. A small population was considered to contain between 20 and 50 plant clumps but a large population was considered to contain more than 50 plant clumps.

At Munmorah *Tetratheca juncea* occurs only in low forest/woodland of the *Angophora costata* complex. Benson (1986) includes *Eucalyptus gummifera*, *E. capitellata* and *Allocasuarina littoralis* as the dominants in the association and classifies the community as 9(g) for the Gosford-Lake Macquarie map sheet. This aptly describes the association at Munmorah except that *Eucalyptus haemastoma* occasionally dominates also. The structure is generally a low open-forest with a low cover of herbs, shrubs, monocotyledons and grasses. Associated species in the understorey are variable but dominants include *Macrozamia communis*, *Acacia myrtifolia*, *Lomandra obliqua*, *Dodonaea triquetra*, *Pimelea linifolia*, *Pultenaea villosa* and *Lambertia formosa*. *Themeda australis* (Kangaroo grass) is always present as the dominating grass, either as a dense or sparse cover. Other grasses such as *Entolasia stricta* can sometimes be present but only as occasional plants.

Populations of *Tetratheca juncea* at Munmorah appear to be confined to narrow, long, smooth hilltops, although the habitat of one collection at Charmhaven nearby, (collection in National Herbarium of New South Wales) is described as 'clay soil alongside creek'. Where it is found on hilltops the population does not extend very far over side slopes and it could not be found alongside drainage lines in the gullies. The Munmorah population appears to be restricted to this topographical feature and appears to be made up of scattered individuals and small populations commonly occurring over a wide area.

Winning (1992) reports that *Tetratheca juncea* occurs in generally the same vegetation type for the larger populations in the Lake Macquarie area but a range of habitats were recorded. Small populations of plants were found to be present in heath vegetation on sands, in shrublands on sandflats, in gullies and in Spotted Gum-Ironbark forest. Kidd (1991) also reports the same vegetation type but in one location, Catherine

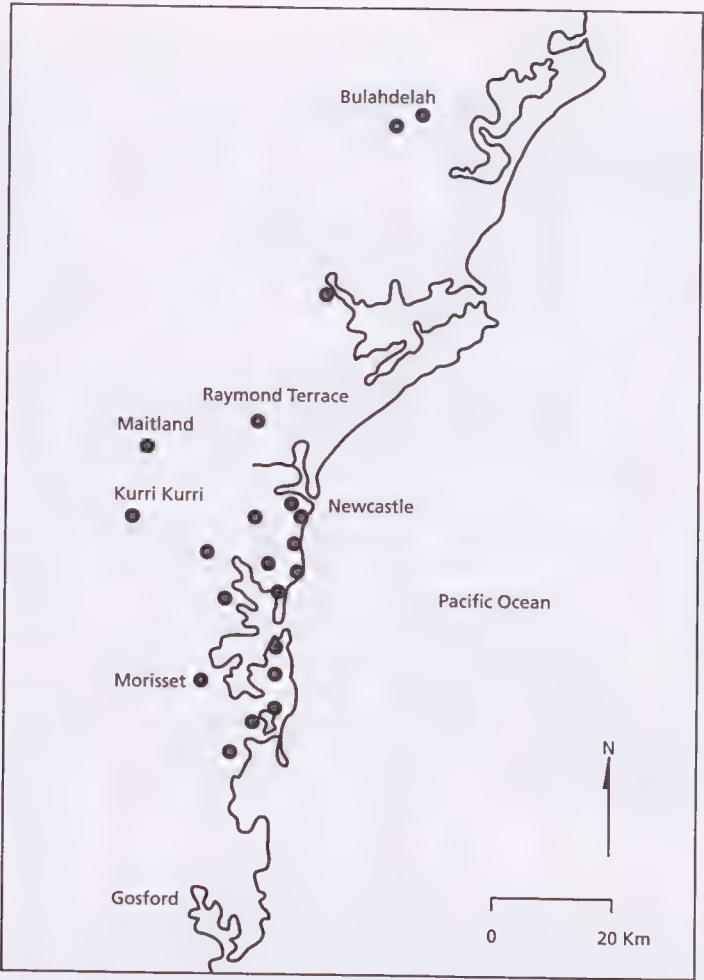


Figure 1. Reported locations of *Tetratheca juncea* from Lake Macquarie–Newcastle–Bulahdelah district.

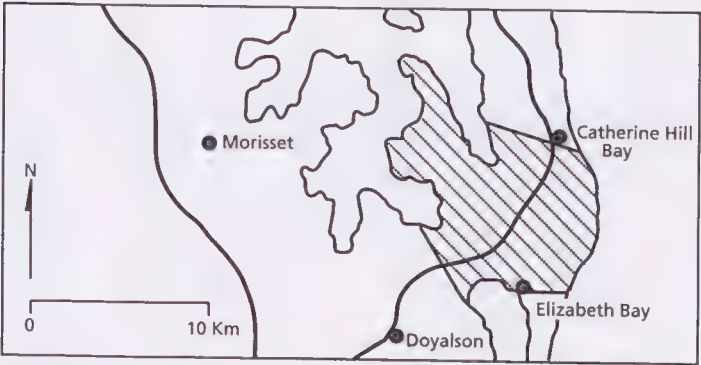


Figure 2. Area at Munmorah showing where *Tetratheca juncea* occurs (shaded).

Table 1 Site attributes for *Tetratheca juncea* at Munmorah. Site numbers refer to grid references on the Catherine Hill Bay 1:25 000 map sheet

Site	Topography	Soil	Vegetation	Distance from the sea	Abundance	Remarks
690275	Plateau	Shallow skeletal sand	<i>Angophora costata</i> complex (Forest)	3km	Isolated plants	Dense cover of <i>Themeda australis</i> and other shrubs
700275	Plateau	Shallow skeletal sand	<i>Angophora costata</i> complex (Low Woodland)	2km	Large population	Sparse ground cover due to wildfire 1990
705281	Plateau	Shallow skeletal sand	<i>Angophora costata</i> complex (Forest)	1.5km	Large population	Dense cover of <i>Themeda australis</i> and other shrubs
703268	Plateau	Shallow skeletal sand	<i>Angophora costata</i> complex (Low stunted Forest)	1km	Large population	Dense cover of <i>Themeda australis</i> and other shrubs
701287	Plateau	Shallow skeletal sand	<i>Angophora costata</i> complex (Forest with some clearing)	2km	Small population	Sparse cover of <i>Themeda australis</i> and other shrubs – disturbed ground
703293	Plateau	Shallow skeletal sand	<i>Angophora costata</i> complex (Forest)	2km	Isolated plants	Dense cover of <i>Themeda australis</i> and other shrubs
702292	Plateau	Shallow skeletal sand	<i>Angophora costata</i> complex (Trees cleared)	2km	Large population	Disturbed ground. Some cover of <i>Themeda australis</i> and other shrubs
709299	Plateau	Shallow skeletal sand	<i>Angophora costata</i> complex (Forest)	2km	Isolated plants	Dense cover of <i>Themeda australis</i> and other shrubs

Hill Bay, the species was present in *Eucalyptus botryoides*, *Angophora* spp.—*Allocasuarina torulosa* forest.

The geology at Munmorah is the Clifton-subgroup of the Narrabeen Group (Uren, 1977). Exposed surfaces through roadside cuttings indicate a shallow sandy soil profile underlain by yellow sedimentary sandstone strata with conglomeritic and gravelly intrusions. Soil derived from this strata is a coarse yellow skeletal sand with little clay material present. Further north in the Lake Macquarie area the main populations tend to occur in clayey soils derived from conglomerates of the same geological formation. Specifically the populations were found to be present on ridges or upper slopes and generally favoured a southerly or easterly aspect (Winning, 1992).

Other soils on hilltops in the Munmorah locality are deeper grey podsolised sands which are also occupied by the *Angophora costata* complex but with a forest structure instead. Moist organic sandy soils and dry podsolised sands are also present where sedgeland of *Ptilanthelium duerstum*, *Leptocarpus tenax* and *Lepyrodia scariosa* and heathlands of *Banksia oblongifolia*, *Hakea bakerana* and *Philotheca salsolifolia* occur. *Tetratheca juncea* does not appear to occur in the latter two habitats. On a broader scale the vegetation between the various populations where the species is now known to occur has not yet been investigated in different localities.

Tetratheca juncea is described as a coastal species (Harden, 1992) but appears to require some degree of shelter. The population at Munmorah does not occur adjacent to the sea and always lies behind the wind-sheared vegetation zone, although at Redhead it occurs in low heath directly exposed to onshore winds (Winning, pers.comm.). Elsewhere the species occurs inland as far as Maitland and Kurri Kurri (Fig. 1). Rainfall ranges from 1160 mm annually at Wyong to 926 mm at Newcastle (Bridgeman, 1984). For the Sydney sites it is about 1100 mm annually (Bureau of Meteorology 1975).

Population size — Munmorah State Recreation Area

Within the Munmorah State Recreation Area plant populations were examined in detail during September 1992. Three main populations are present which are all in close proximity to one another (Table 2). It is an easy task to count the number of groups of plants along the narrow plateaux but it is difficult to decide whether plants are comprised of a number of separate individuals or are simply multi-stemmed plants. Some plants can occupy an area of 0.5 m² comprising 50–60 individual stems. In this survey, therefore, counts of plants are referred to as 'plant clumps'.

Table 2. Plant Clumps present in the Munmorah State Recreation Area. Site Numbers refer to grid co-ordinates on the Catherine Hill Bay 1:25 000 map sheet

Site	No. of plant clumps	Aspect
700275	103	North-east
	51	South-west
705281	27	North-east
	31	South-west
703268	44	East
	61	West
713273	6	South

Results

Populations of *Tetratheca juncea* could be located if conditions of topography, soil, vegetation and distance from the sea were suitable (Table 1). If one condition was unsuitable it was found that the species was not present. The Munmorah population could be related to remnant land surfaces with topography being the main determinant. Further north in the Lake Macquarie area the same habitat conditions may not necessarily apply.

The populations of *Tetratheca juncea* in the Sydney area could be expected to have occurred on similar soils, in the sense that they were infertile, shallow, stony and skeletal. Benson and Howell (1990) describe the Hawkesbury Sandstone soils in Sydney as being invariably sandy and containing rock fragments in areas of rugged slopes and plateaux. Records for locations in the Lake Macquarie and Newcastle areas (Table 3) show that it probably also occurred in drier habitats.

There are two secondary factors that appear to influence the size of the populations of *Tetratheca juncea*. These affect the abundance of plants in the population rather than the presence or absence of the population. Abundant occurrences of plants appears to be related to both the degree of canopy cover and associated understorey cover. Isolated plants occurred under a denser canopy but in low very open-woodland the abundance of plants appears to be greater. Furthermore the abundance of plants is greater in areas of sparse understorey cover in some cases. It is thought that as the cover of *Tetratheca australis* (Kangaroo Grass) increases, competition restricted the availability of sites for *Tetratheca juncea* to survive. In one area of the Munmorah State Recreation Area, the number of plants was relatively abundant where fire had burnt the understorey grass cover the previous year. The populations further north were also found to occur with open grassy understorey (Winning, 1992).

Tetratheca juncea survives fire but it is not known whether it resprouts or re-seeds. However it did flower and set seed the year following fire at Munmorah in 1991 and again in 1992. Field observations revealed that it flowered between the beginning of August through to January and sets seed beginning in October but no information is available on the effects of the species from frequent fire. Winning (1992) points out that the populations that were near Seahampton in 1986 were burnt in a May 1991

Table 3. Habitat of *T. juncea* in the Lake Macquarie–Newcastle district shown from collections in the National Herbarium of New South Wales and reported by Gutteridge Haskins and Davey Pty Ltd (1986). Rainfall Data from Bridgeman (1984)

Site	Soils	Vegetation	Topography	Annual average rainfall (mm)
Swansea	No data	<i>Angophora costata</i> complex	No data	1100
North of Lake Munmorah	Sandy soil	Open dry sclerophyll forest	No data	1160
Belmont	Sandy soil	No data	No data	1100
Raymond Terrace	Shale	Dry sclerophyll forest	No data	1031
Redhead	Aeolian sands	<i>Banksia aemula</i> heathland	Sand dunes	926
Killingworth	No data	open forest and woodland	South facing ridges and slopes	1050

fire, but could not be located in September 1991. At Jewells Swamp frequent fires (five fires in nine years) caused the plants to virtually disappear. It may be that the species requires twelve months for germination to occur following fire and to perpetuate the species it may have to be managed in relation to the degree of understorey vegetation cover although more research is needed for confirmation.

Discussion

How can long-term management be achieved, when the conservation of the species may be inadequate? The population in the Munmorah Recreation Area is less than 5.6 hectares whilst the remainder of the known population unprotected covers at least an area of 16 hectares on the narrow ridges (Figure 2). This excludes associated catchment areas. Winning (1992) recorded 1416 individuals and plant clumps for site 700275 in September 1991 compared with an estimate of 154 clumps from this survey but much of the former population may be present in road reserves. The National Parks and Wildlife Service is only able to manage the population on lands held within its authority. Remaining lands where the population occurs are privately owned and the future of *Tetratheca juncea* on those lands cannot be assured. However it is noted that there are 50 plants in the Awabakal Nature Reserve and a further 1434 plants in Glenrock State Recreation area (Winning, 1992).

The locations where the populations of *Tetratheca juncea* occur will be subject to land development and infrastructural pressures even within the Munmorah Recreation Area. Hilltops have available areas of flatlands and have been used for roads, quarries, spoil heaps, residential development and services. It appears some previous surveys have failed to identify the species and the population here has now disappeared under grassed embankments associated with this development. This development scenario combined with more frequent fire patterns is reducing the population significantly. It can only be anticipated, based on current trends, that the conservation of the Munmorah population is in doubt unless steps are taken to extend the reserved area. A population of 1000 plants for *Tetratheca juncea* may not necessarily be considered adequate to conserve the species. The plants are so thinly populated in the field over small areas with large areas between populations that they could be considered at risk until such times that a large catchment area is included with any reserve proposal.

A specific search has so far has only proceeded as far north as the Wallarah Colliery and west to Point Wolstoncroft but there are records of *Tetratheca juncea* further north and west on similar topographic features and within a similar rainfall band (Figure 1). Detailed surveys need to be undertaken to ascertain the total population and its future conservation potential. It is anticipated that hilltops in the locality with natural vegetation of the *Angophora costata* complex would contain populations of *Tetratheca juncea*. BHP Australia recently commissioned a survey on the distribution of *Tetratheca juncea* and have now found a number of new populations west of Lake Macquarie. In addition research is proceeding into cultivation using seed germination and cutting trials.

Conclusions

The occurrence of populations of *Tetratheca juncea* at Munmorah can be predicted on site conditions of topography, soil, vegetation and distance from the sea. This information will be useful for future surveys. However the future of the population at Munmorah is at risk unless planning strategies change. The vulnerable coding should remain until these planning strategies change and additional reserve area is sought to reserve the population elsewhere in a larger catchment scheme. Conserving isolated populations on a subcatchment basis may not be amenable to the survival of a population. And the lack of scientific data on the species should not be used as a basis for approving development when populations occur.

Acknowledgments

Andrew Sourry is acknowledged for his field assistance. The co-operation of Shortland Electricity, Coal and Allied Industries, and Wyong Shire Council to protect the species from damage outside the Munmorah Recreation Area is gratefully acknowledged. Also many thanks to ranger, Neil Martin, who provided details of its initial location in the Munmorah Recreation Area. Doug Benson and Geoff Winning edited and made critical comments on the manuscript, Kathy Macdonald compiled the figures, Teresa James verified my collections and the National Parks and Wildlife Service supplied details of collections from their database. Vanessa Laybutt typed the manuscript.

References

- Bartrim, G. and Martin, A. (1986) Notes on the distribution and abundance of the vulnerable plant species *Tetratheca juncea* (unpubl.) Copy held in library of New South Wales National Parks and Wildlife Service.
- Benson, D.H. (1986) The vegetation of the Gosford and Lake Macquarie 1:100 000 vegetation map sheet *Cunninghamia* 1(4): 467-489.
- Benson, D.H. and Howell, J. (1990) *Taken for granted — the bushland of Sydney and its suburbs* (Kangaroo Press: Kenthurst)
- Bridgeman, H.A. (1984) Climatic atlas of the Hunter region. Department of Geography, University of Newcastle.
- Briggs, J.D. & Leigh, J.H. (1988) Rare or threatened Australian plants. Special publication no. 14 (Australian National Parks and Wildlife Service: Canberra)
- Bureau of Meteorology (1975) Climatic averages New South Wales. (Australian Government Publishing Service: Canberra).
- Gutteridge, Haskins and Davey Pty Ltd (1986) National highway — environmental impact statement section Wakefield to Minmi assessment of impact on vegetation supplementary report.
- Harden G. J. (1992) *Flora of New South Wales Volume 3* (New South Wales University Press: Kensington)
- Kidd R.W. (1991) A summary of sightings of *Tetratheca juncea* within the Lake Macquarie area. Internal unpublished document. Lake Macquarie City Council.
- Uren, R.L. (1977) Mangrove — Gosford — Lake Macquarie geological map sheet. (Geological Survey of New South Wales: Sydney)
- Winning G. (1992) Conservation status of rare plants in the Lake Macquarie area report prepared for Lake Macquarie City Council by Shortland Wetlands Centre.

Final manuscript received 30 January 1993

Manuscript accepted 24 March 1993

Vegetation of Mulligans Flat, A.C.T.

B.J. Lepschi

Abstract

Lepschi, B.J.* (24 Fullwood St., Weston, Canberra, ACT, Australia 2611) 1993. *Vegetation of Mulligans Flat, A.C.T.* *Cunninghamia* 3(1) 155–166. The vegetation and flora of the Mulligans Flat area, A.C.T. (approximately 35°11'S 149°08'E), are described from data collected during 1988–1989, with some records from 1991 and 1992. A total of 276 species have been recorded, of which 180 are native, 93 introduced and three are persisting from cultivation.

Introduction

The Gungahlin area of the northern A.C.T. (Figure 1) is currently being developed as Canberra's next 'satellite town'. Although most of the vegetation in the area has been cleared, and the land used for livestock grazing since at least the 1850s (National Capital Development Commission (hereafter 'NCDC'), 1988a), a few remnants of the original vegetation remain. The largest and best-preserved of these is situated at Mulligans Flat, in the north-east part of the area (35°11'S 149°08'E; Figure 1). Mulligans Flat has been identified as an area of ecological significance in the A.C.T. (Frawley 1991, NCDC 1988a, b). The aim of this paper is to provide floristic data to supplement the limited information currently available on the vegetation.

The study area

For the purposes of this paper, the circumscription of the Mulligans Flat area differs slightly from the previous definition in NCDC (1988a, b), in that the southern and north-eastern borders have been extended (Figure 1), to take in areas of woodland, and the northernmost part of the 'Gungahlin Quartz Ridge' (NCDC 1988b). The Gundaroo road verge is also included, with the total study area covering 275 ha.

Mulligans Flat is currently leasehold grazing land, although stock (sheep) will be removed from the area when it gains full reserve status. The area has been utilised as grazing land since at least the 1850s; limited clearing of vegetation has taken place and a number of small stock dams (most supporting some aquatic/wetland vegetation) have been constructed. There is a shearing shed and a stock race, both of comparatively recent origin. Two vehicle tracks (used by the landholders only), run roughly east-west in the southern part of the study area (Figure 1). Little physical evidence of former habitation remains (NCDC 1988a), except for some plantings of introduced species (e.g.: **Pinus radiata*, **Photinia serrulata*) on the site of the former (closed in the 1920s) Mulligans Flat School in the extreme south-western corner of the area (see Figure 1), and tree plantings (local eucalypt species) along the former Bungendore to Ginninderra road, which was in use during the 1880s, in the extreme south of the study area.

* Present address: Australian National Herbarium, CSIRO Division of Plant Industry, GPO Box 1600, Canberra City, Australia 2601.

There is considerable support from both the scientific and general communities to have it declared a Nature Reserve (Frawley 1991).

Limited grazing and/or browsing still occurs by kangaroos and wallabies, and small numbers of rabbits. The area has been burnt by bushfires in the past, with the most recent fire in 1979 (K. Kukolic, pers. comm.).

Topography and geology

The topography is undulating, with two moderately sloping ridges (rising to approximately 680 m) running north-east to south-west separated by a flat valley (Frawley 1991). The geology consists largely of a formation known as the 'Canberra Formation', predominantly siltstone and mudstone, with a small area of the volcanic rock, dacite, on the north-eastern edge. Some quartz outcropping is also present (NCDC 1988b).

Soils of the surrounding region (and Mulligans Flat) are described generally in Gunn *et al.* (1969) and specifically for the Gungahlin area in NCDC (1988b). Shallow lithosols (often reddish in colour) are found on the ridges and slopes, with solod soils on the flatter parts of the area; these are subject to waterlogging following periods of rain (NCDC 1988a; B.J. Lepschi pers. obs.). Areas of solodic and solod solonetzic soil are present on the north-eastern edge of Mulligans Flat.

Two small ephemeral creeks and their tributaries run approximately parallel to the ridges in the valley area (with another on the areas eastern edge), and it is on these that the stock dams mentioned above are situated. Limited gully and sheet erosion is present throughout the area, associated mainly with the vehicle tracks.

Average annual rainfall at the village of Hall (35°09'S 149°03'E) approximately eight km to the west of the study area, is 700 mm, with a peak in October. Average maximum temperature at Canberra (35°15'S 149°08'E) approximately 12 km to the south of the study area, for January is 28°C and average minimum temperature in July is 0°C (information supplied by Bureau of Meteorology, Canberra).

Vegetation

Three broad vegetation types occur at Mulligans Flat, namely open-forest, woodland and grassland. These are described individually below and their approximate occurrence is shown in Figure 2.

Open-forest occurs predominantly on the shallower soils of the ridges and slopes. Dominant species are *Eucalyptus macrorhyncha*, *E. rossii* and *E. mannifera*, with some *E. goniocalyx* (this species occurring mostly towards the ridge-tops). Scattered *E. blakelyi* and *E. melliodora* occur on deeper soils on the lower slopes. There is much eucalypt regeneration and saplings are common in the understorey, along with small trees such as *Acacia dealbata*, *A. parramattensis* and *Exocarpos cupressiformis*, and shrubs including *Hibbertia obtusifolia*, *Brachyloma daphnoides*, *Melichrus urceolatus*, *Acacia gunnii*, *Daviesia* spp., *Dillwynia sericea*, and *Pultenaea* spp. The groundlayer consists of various grasses and herbs, with the following species all common: *Aristida ramosa*, *Danthonia* spp., *Dichelachne micrantha*, *Poa sieberiana* subsp. *sieberiana*, *Lomandra* spp., *Gonocarpus tetragynus*, *Hydrocotyle laxiflora*, *Wahlenbergia* spp., *Stylidium graminifolium*, and *Goodenia hederacea* subsp. *hederacea*.

Areas of actively regenerating woodland occur throughout Mulligans Flat; some of these appear to be the result of past clearing of the open forest formation (Frawley 1991, NCDC 1988b), and all of the eucalypts recorded for the latter vegetation type

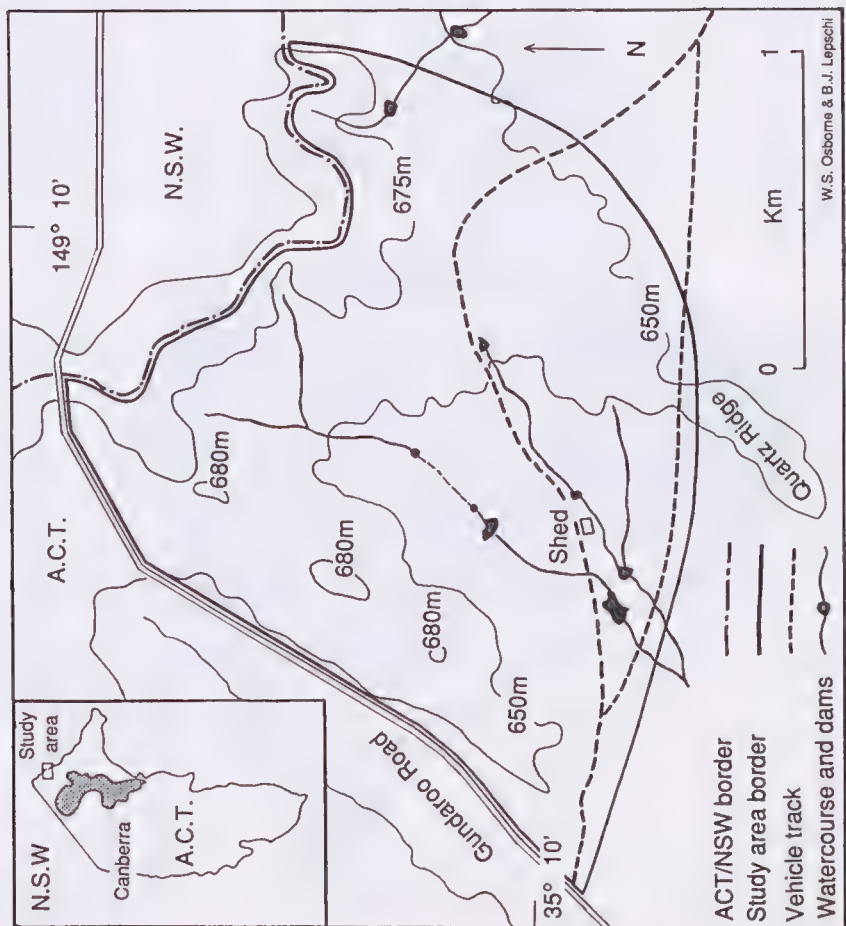


Figure 1. Map of study area showing major features and location (inset)

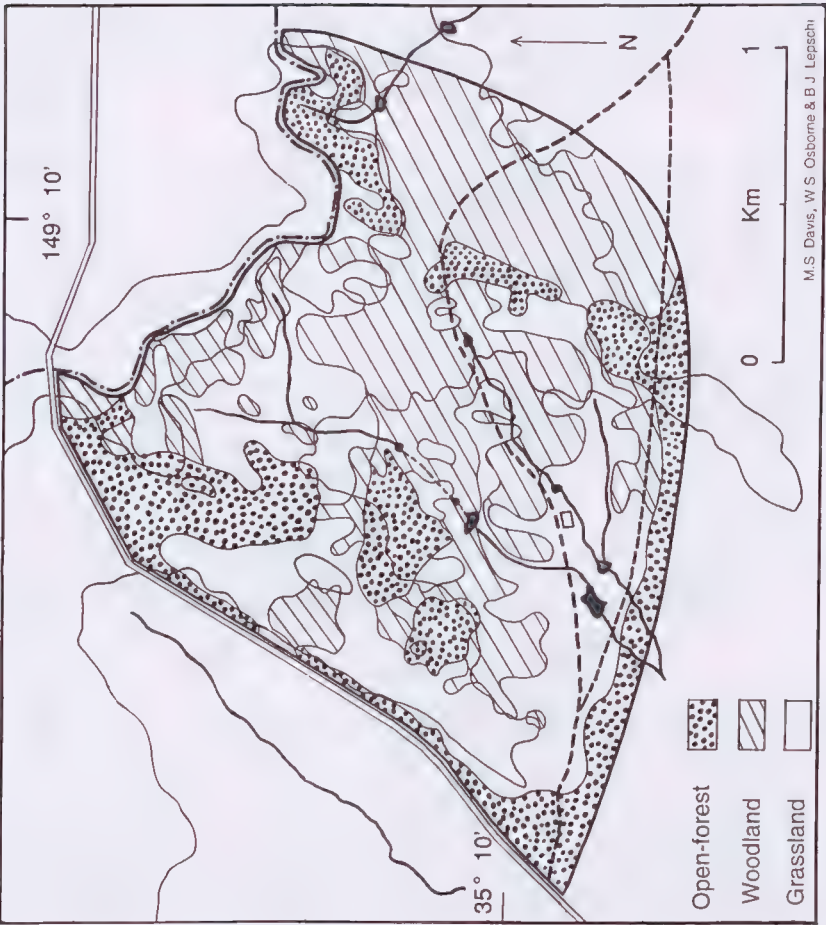


Figure 2. Vegetation of Mulligans Flat

can be found in the woodland areas. On flatter sites with deeper soil, woodland dominated by *Eucalyptus blakelyi* and *E. melliodora* is found, with scattered *E. bridgesiana* and *E. rubida* subsp. *rubida*. The latter is frequent along the creek bordering an area of open grassland near the shearing shed. The understorey is generally sparse, with eucalypt saplings and scattered stands of *Acacia* spp. (mainly *A. dealbata*) and shrubs including *Hibbertia obtusifolia*, *Lissanthe strigosa*, *Melichrus urceolatus*, * *Rosa rubiginosa*, *Daviesia genistifolia*, and *Cryptandra amara* var. *longiflora*. Grasses and herbs again make up the groundcover, with *Aristida ramosa*, *Bothriochloa macra*, *Danthonia* spp., *Eragrostis benthamii*, *Panicum effusum* var. *effusum*, *Stipa bigeniculata*, *S. scabra* subsp. *falcata*, *Themeda australis*, *Wurmbea dioica* subsp. *dioica*, *Drosera peltata*, *Glycine tabacina*, * *Trifolium arvense*, * *T. dubium*, *Hydrocotyle laxiflora*, *Wahlenbergia* spp., * *Hypochaeris* spp., *Solenogyne dominii*, and *Vittadinia muelleri* all commonly occurring.

Patches of grassland occur throughout the area; *Panicum effusum* var. *effusum* and *Themeda australis* are common components, particularly where only light grazing has taken place. Other frequent species include *Danthonia* spp., *Eragrostis benthamii*, *Stipa bigeniculata*, and *S. scabra* subsp. *falcata*. In disturbed sites or areas subjected to heavier grazing, * *Aira* spp., *Bothriochloa macra*, and *Chloris truncata* are also common.

Species list

All species recorded by the author on (generally monthly) visits to the area during the period May 1988 to August 1989 and again in April 1991 and April and November 1992 are listed (Table 1). It was not possible to cover the entire area on each occasion. Also included are species recorded by M.S. Davis during survey work for Scott and Furphy Pty Ltd, in January 1992. Family concepts (except for the recognition of the Lobeliaceae) and nomenclature follow Hnatiuk (1990); where a name differs from the latter, the author and relevant reference is cited. Vouchers were generally not collected; those that were are lodged in the Australian National Herbarium, CSIRO, Canberra (CANB; authors collections) and the Herbarium of the Australian National Botanic Garden, Canberra (CBG; M.S. Davis's collections).

The list is not exhaustive, and many more species can be expected, particularly when stock have been removed from the area.

Table 1. List of plant species recorded at Mulligans Flat, A.C.T. (1988–1992).

Species not indigenous to Australia are marked with an asterisk (*); indigenous species not native to the Canberra area are marked with a hash symbol (#).

For species recorded by M.S. Davis (see above), the abbreviation 'MD' is included after the name in brackets.

A subjective indication of frequency and abundance (based on that used by Helman *et al* 1988) is given for each species. Abbreviations used are:

W – widespread

L – localised

C – common

U – uncommon

R – rare

P – persisting from former cultivation, but not naturalised

PTERIDOPHYTES

Adiantaceae

<i>Cheilanthes austrotenuifolia</i>	WC
<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i> (MD)	LU

Ophioglossaceae

<i>Ophioglossum lusitanicum</i> subsp. <i>coriaceum</i> (see Wilson 1990)	LC
---	----

GYMNOSPERMS

Pinaceae

* <i>Pinus radiata</i>	LR
------------------------	----

ANGIOSPERMS

MONOCOTYLEDONS

Cyperaceae

<i>Carex inversa</i>	LU
<i>Cyperus sanguinolentus</i>	LC
<i>Eleocharis acuta</i>	LC
<i>Schoenus apogon</i>	LC

Eriocaulaceae

<i>Eriocaulon scariosum</i>	LR
-----------------------------	----

Hydrocharitaceae

<i>Ottelia ovalifolia</i>	LC
---------------------------	----

Iridaceae

?* <i>Sisyrinchium</i> sp. A (sensu Wilson in prep.; = <i>S. micranthum</i> Cav. (see Cooke 1986))	LR
--	----

Juncaceae

<i>Juncus australis</i>	WU
* <i>Juncus articulatus</i>	LU
<i>Juncus bufonius</i>	WU
* <i>Juncus capitatus</i>	WU
<i>Juncus filicaulis</i>	WC
<i>Juncus holoschoenus</i>	LC
<i>Juncus homalocaulis</i>	WU
<i>Juncus sarophorus</i>	LC
<i>Juncus subsecundus</i>	WC
<i>Juncus vaginatus</i>	LU
<i>Luzula flaccida</i>	WC

Liliaceae

<i>Bulbine bulbosa</i>	LR
<i>Burchardia umbellata</i>	LR
<i>Caesia calliantha</i>	LR
<i>Dianella revoluta</i> subsp. <i>revoluta</i>	LR
<i>Dichopogon fimbriatus</i>	LU
<i>Hypoxis hygrometrica</i> var. <i>hygrometrica</i>	LC
<i>Hypoxis vaginata</i> var. <i>vaginata</i>	LU
<i>Thysanotus tuberosus</i> subsp. <i>tuberosus</i>	LR
<i>Tricoryne elatior</i>	WU
<i>Wurmbea dioica</i> subsp. <i>dioica</i>	WC

Orchidaceae

<i>Dipodium punctatum</i> (MD)	LR
<i>Diuris</i> sp.	LR
<i>Eriochilus cucullatus</i>	LR
<i>Microtis unifolia</i>	LC
<i>Thelymitra pauciflora</i> (MD)	LR

Poaceae

<i>Agrostis avenacea</i> var. <i>avenacea</i>	LC
* <i>Aira cupaniana</i>	WC
* <i>Aira elegantissima</i>	WC
<i>Amphibromus nervosus</i>	LC
<i>Aristida ramosa</i> R. Br. (see Simon 1992)	WC
* <i>Avena barbata</i>	LR
* <i>Avena fatua</i>	LC
<i>Bothriochloa macra</i>	WC
* <i>Briza maxima</i>	LC
* <i>Briza minor</i>	WU
* <i>Bromus catharticus</i>	LC
* <i>Bromus diandrus</i>	LU
* <i>Bromus hordeaceus</i> subsp. <i>molliformis</i>	LR
* <i>Bromus madritensis</i>	LR
<i>Chloris truncata</i>	WC
<i>Cynodon dactylon</i>	WU
* <i>Cynosurus echinatus</i>	LC
<i>Danthonia auriculata</i> (MD)	LU
<i>Danthonia caespitosa</i>	WC
<i>Danthonia carphoides</i> var. <i>carphoides</i>	WC
<i>Danthonia laevis</i> (MD)	WC
<i>Danthonia monticola</i> (MD)	LU
<i>Danthonia pallida</i>	WC
<i>Danthonia penicillata</i> (MD)	WC
<i>Danthonia pilosa</i> var. <i>pilosa</i>	WU

Poaceae (cont'd)

<i>Danthonia racemosa</i> var. <i>racemosa</i> (MD)	WU
<i>Dichelachne micrantha</i>	LC
<i>Elymus scaber</i> var. <i>scaber</i> (sensu Jacobs in prep.)	WU
<i>Enneapogon nigricans</i>	WU
<i>Eragrostis benthamii</i>	WU
* <i>Hordeum leporinum</i> Link.(sensu Jacobs in prep.)	LR
* <i>Lolium perenne</i>	LU
* <i>Lolium rigidum</i>	LU
<i>Microlaena stipoides</i> var. <i>stipoides</i>	WU
* <i>Nassella trichotoma</i>	LR
<i>Panicum effusum</i> var. <i>effusum</i>	WC
* <i>Paspalum dilatatum</i>	LC
* <i>Phalaris aquatica</i>	LU
* <i>Phleum pratense</i>	LU
<i>Poa sieberiana</i> var. <i>sieberiana</i>	LC
* <i>Rostraria cristata</i> (MD)	LR
* <i>Setaria gracilis</i> var. <i>paucisetia</i>	LC
<i>Stipa bigeniculata</i>	WC
<i>Stipa densiflora</i>	LU
<i>Stipa scabra</i> subsp. <i>falcata</i>	WC
<i>Themeda australis</i> (R.Br) Stapf.	
(sensu Jacobs in prep.)	WC
* <i>Vulpia bromoides</i>	WU

Potamogetonaceae

<i>Potamogeton tricarlinatus</i>	LC
----------------------------------	----

Xanthorrhoeaceae

<i>Lomandra filiformis</i> subsp. <i>coriacea</i>	WC
<i>Lomandra multiflora</i> subsp. <i>multiflora</i>	
(see Lee and Macfarlane 1986)	WU

DICOTYLEDONS**Amaranthaceae**

<i>Alternanthera denticulata</i>	LU
<i>Alternanthera</i> sp. A (sensu Jacobs & Lapinpuro 1990)	WU

Apiaceae

<i>Daucus glochidiatus</i> (s. lat.)	WU
<i>Eryngium rostratum</i> Cav. (see Powell & Wiecek 1992)	LU
<i>Hydrocotyle laxiflora</i>	WC
<i>Hydrocotyle peduncularis</i> (s. lat.)	LC

Apocynaceae

* <i>Vinca major</i>	P
----------------------	---

Asteraceae

* <i>Arctotheca calendula</i>	WU
<i>Brachycome rigidula</i>	WU
<i>Calocephalus citreus</i>	LR
* <i>Carduus pycnocephalus</i>	LR
* <i>Carthamus lanatus</i>	LU
<i>Cassinia aculeata</i>	LR
<i>Cassinia longifolia</i>	LR

Asteraceae (cont'd)

<i>Cassinia quinquefaria</i>	WU
<i>Centipeda cunninghamii</i>	LC
<i>Centipeda minima</i>	LU
* <i>Chondrilla juncea</i>	LR
<i>Chrysocephalum apiculatum</i> (Labill.) Steetz	WU
Steetz (s. lat.) (syn. <i>Helichrysum apiculatum</i> (Labill.) DC.; see Anderberg 1991)	
<i>Chrysocephalum semipapposum</i> (Labill.) Steetz	LR
(s. lat.) (syn. <i>Helichrysum semipapposum</i> (Labill.) DC.; see Anderberg 1991)	
* <i>Cirsium vulgare</i>	WC
* <i>Conyza albida</i>	LR
<i>Cotula australis</i>	WU
<i>Craspedia variabilis</i> Everett & Doust	LC
(see Everett & Doust 1992)	
<i>Cymbonotus preissianus</i>	WU
<i>Euchiton gymnocephalus</i> (DC.) A. Anderb.	LC
(syn. <i>Gnaphalium gymnocephalum</i> DC.; see Anderberg 1991)	
<i>Euchiton sphaericus</i> (Willd.) A. Anderb.	WU
(syn. <i>Gnaphalium sphaericum</i> Willd.; see Anderberg 1991)	
* <i>Gnaphalium americanum</i> Miller (sensu Everett 1992)	LU
* <i>Hypochaeris glabra</i>	WU
* <i>Hypochaeris radicata</i>	WC
<i>Isoetopsis graminifolia</i>	LR
<i>Leptorhynchus squamatus</i>	LR
* <i>Logfia gallica</i>	LC
<i>Microseris lanceolata</i> (s. lat.)	WU
<i>Pseudognaphalium luteo-album</i>	WU
<i>Senecio quadridentatus</i>	WU
<i>Solenogyne dominii</i>	WC
<i>Solenogyne gunnii</i>	LU
* <i>Sonchus asper</i> subsp. <i>glaucescens</i>	LU
* <i>Sonchus oleraceus</i>	WU
* <i>Taraxacum</i> sp. agg.	WU
* <i>Tolpis umbellata</i>	WU
* <i>Tragopogon dubius</i>	LR
<i>Triptilodiscus pygmaeus</i>	WC
<i>Vittadinia cuneata</i> var. <i>cuneata</i>	WU
<i>Vittadinia muelleri</i>	WC

Boraginaceae

<i>Cynoglossum suaveolens</i>	LR
* <i>Echium plantagineum</i>	LC
* <i>Myosotis discolor</i>	WU

Brassicaceae

* <i>Hirschfeldia incana</i>	LU
* <i>Lepidium africanum</i>	LU
* <i>Sisymbrium officinale</i>	LC

Campanulaceae

<i>Wahlenbergia communis</i>	WC
<i>Wahlenbergia graniticola</i> (MD)	LR
<i>Wahlenbergia multicaulis</i> (MD)	LR
<i>Wahlenbergia stricta</i>	WC

Table 1. (cont'd)

Caryophyllaceae

* <i>Moenchia erecta</i>	WU
* <i>Paronychia brasiliiana</i>	LU
* <i>Petrorhagia nanteuilii</i>	WU
* <i>Polycarpon tetraphyllum</i>	LU
<i>Scleranthus diander</i>	LR
* <i>Silene gallica</i> var. <i>gallica</i>	LR
* <i>Spergularia rubra</i>	WU
* <i>Stellaria media</i>	LU
<i>Stellaria pungens</i>	WU

Chenopodiaceae

* <i>Chenopodium album</i>	LR
<i>Chenopodium pumilio</i>	LC
<i>Einadia nutans</i> subsp. <i>nutans</i>	WU

Clusiaceae

<i>Hypericum gramineum</i>	WC
----------------------------	----

Convolvulaceae

<i>Convolvulus erubescens</i>	WU
<i>Dichondra repens</i>	LU

Crassulaceae

<i>Crassula sieberiana</i> subsp. <i>tetramera</i>	LC
--	----

Dilleniaceae

<i>Hibbertia obtusifolia</i> (s. lat.)	WC
--	----

Droseraceae

<i>Drosera peltata</i>	WC
------------------------	----

Epacridaceae

<i>Astroloma humifusum</i>	LU
<i>Brachyloma daphnoides</i>	LC
<i>Leucopogon virgatus</i>	WU
<i>Lissanthe strigosa</i>	WU
<i>Melichrus urceolatus</i>	WC
(bushy form with hairy, acute sepals and acuminate petals; see Burbidge & Gray 1970)	

Euphorbiaceae

<i>Chamaesyce drummondii</i> (Boiss) Hassall	WU
(see James & Harden 1990)	
<i>Poranthera microphylla</i>	WU

Fabaceae

<i>Bossiaea buxifolia</i>	LU
<i>Bossiaea prostrata</i>	LU
* <i>Cytisus</i> sp.	P
<i>Daviesia genistifolia</i>	WU
<i>Daviesia leptophylla</i>	LU
<i>Daviesia mimosoides</i> R. Br. subsp. <i>mimosoides</i> (see Crisp 1991)	LR
<i>Desmodium brachypodum</i> (MD)	LR
<i>Desmodium varians</i>	LU
<i>Dillwynia sericea</i>	LC
<i>Glycine clandestina</i> (s. lat.)	WU
<i>Glycine tabacina</i> (s. lat.)	WU
<i>Gompholobium huegelii</i> (MD)	LR
<i>Hardenbergia violacea</i>	LU

Fabaceae (cont'd)

<i>Hovea linearis</i>	LR
<i>Indigofera australis</i>	WU
* <i>Medicago arabica</i>	WU
* <i>Medicago polymorpha</i> (see Weston 1991a)	LR
* <i>Medicago sativa</i>	LR
<i>Psoralea adscendens</i>	LR
<i>Pultenaea microphylla</i> Sieber ex DC.	LU
(see Weston 1991b)	
<i>Pultenaea procumbens</i>	WC
* <i>Trifolium angustifolium</i>	LU
* <i>Trifolium arvense</i>	WC
* <i>Trifolium campestre</i>	WU
* <i>Trifolium dubium</i>	WU
* <i>Trifolium glomeratum</i>	WR
* <i>Trifolium repens</i>	WU
* <i>Trifolium striatum</i> (MD)	LR
* <i>Trifolium subterraneum</i>	LU
* <i>Vicia sativa</i> subsp. <i>sativa</i>	LR

Gentianaceae

* <i>Centaurium erythraea</i>	WC
<i>Sebaea ovata</i>	LU

Geraniaceae

* <i>Erodium botrys</i>	LR
* <i>Erodium cicutarium</i>	LC
* <i>Geranium molle</i>	LC
<i>Geranium solanderi</i> var. <i>solanderi</i>	WU

Goodeniaceae

<i>Goodenia hederacea</i> Smith subsp. <i>hederacea</i> (See Carolin 1992)	WC
<i>Velleia paradoxa</i>	WU

Haloragaceae

<i>Haloragis heterophylla</i>	WC
<i>Gonocarpus tetragynus</i>	WC
<i>Myriophyllum crispatum</i>	LC

Lamiaceae

* <i>Marrubium vulgare</i>	LR
<i>Mentha diemenica</i> (MD)	LR
<i>Mentha</i> sp. aff. <i>diemenica</i> (sensu Burbidge & Gray 1970)	WU
* <i>Salvia verbenaca</i>	LR

Linaceae

* <i>Linum trigynum</i>	WR
-------------------------	----

Lobeliaceae

<i>Isotoma fluviatilis</i>	LC
----------------------------	----

Loranthaceae

<i>Amyema miquelii</i>	WC
<i>Amyema pendulum</i> subsp. <i>pendulum</i>	LR

Lythraceae

<i>Lythrum hyssopifolia</i>	WU
-----------------------------	----

Malaceae

- **Crataegus monogyna* (see Harden & Rodd 1990b) LR
 **Pyracantha angustifolia* LR

Malvaceae

- **Modiola caroliniana* LU

Mimosaceae

- # *Acacia baileyana* LR
Acacia dealbata WC
Acacia gunnii LU
Acacia implexa LU
Acacia mearnsii LU
Acacia parramattensis LC

Myrtaceae

- Eucalyptus blakelyi* WC
Eucalyptus bridgesiana LU
Eucalyptus dives (MD) LU
Eucalyptus goniocalyx LC
Eucalyptus macrorhyncha Benth. WC
 (see Brooker and Kleinig 1990)
Eucalyptus mannifera Mudie (see Brooker & Kleinig 1990) WC
Eucalyptus melliodora WC
Eucalyptus rossii LU
Eucalyptus rubida Deane & Maiden subsp. rubida (see Hill and Johnson 1991) WU

Onagraceae

- Epilobium billardierianum* subsp. cinereum WU

Orobanchaceae

- **Orobancha minor* LR

Oxalidaceae

- **Oxalis* sp. A (see Conn 1992) LU
Oxalis exilis LR
Oxalis perennans WU

Papaveraceae

- **Papaver somniferum* subsp. setigerum (see Jacobs 1990) LR

Plantaginaceae

- **Plantago coronopus* subsp. commutata LC
Plantago gaudichaudii LR
 **Plantago lanceolata* WU
Plantago varia (sensu Briggs et al 1977) LC

Polygonaceae

- Persicaria prostrata* LC
 **Polygonum arenastrum* LU
 **Rumex acetosella* WU
Rumex brownii WC
 **Rumex crispus* LC

Portulacaceae

- Montia fontana* subsp. ?*chondrosperma* LC
Portulaca oleracea (sensu West 1990) LC

Primulaceae

- **Anagallis arvensis* (red-flowered form; see Makinson 1990) WU

Ranunculaceae

- Ranunculus lappaceus* WU
Ranunculus sessiliflorus var. *sessiliflorus* LR

Rhamnaceae

- Cryptandra amara* var. *longiflora* WU

Rosaceae

- Acaena novae-zelandiae* LR
Acaena ovina (s. str.; see Harden & Rodd 1990a) WC
 **Photinia serrulata* P
 **Prunus* sp. LR
 **Rosa rubiginosa* WU

Rubiaceae

- Asperula conferta* WU
 **Galium divaricatum* WU
Galium gaudichaudii LR
 **Sherardia arvensis* LC

Santalaceae

- Exocarpos cupressiformis* WU

Scrophulariaceae

- **Linaria pelisseriana* WU
 **Parentucellia latifolia* LU
 **Verbascum thapsus* LR
 **Veronica arvensis* LR

Solanaceae

- **Solanum nigrum* LR

Stylidaceae

- Stylidium graminifolium* LC

Thymelaeaceae

- Pimelea curviflora* var. *sericea* WU

Violaceae

- Viola betonicifolia* (see James 1990) LR

Discussion

The vegetation and floristics of Mulligans Flat show similarities to other comparable areas in the A.C.T., such as Black Mountain Reserve (Gray & McKee 1969) and the Ainslie-Majura Reserve (Ingwersen *et al.* 1974), although neither of these reserves contain such large areas of woodland or grassland as at Mulligans Flat. The presence of species such as *Acacia parramattensis*, *Pultenaea microphylla*, *Eucalyptus gonicalyx* and possibly (see below), *Cheiranthra cyanea*, point to an association with vegetation of similar areas to the north of Mulligans Flat (i.e.; the northern part of the Southern Tablelands of N.S.W.), where these species are more abundant and widespread than in the A.C.T. (B.J. Lepschi unpubl.).

Acacia parramattensis, *Bossiaea prostrata*, *Desmodium brachypodum* and *Eucalyptus gonicalyx*, four species recorded from the study area, are regarded as uncommon in the A.C.T. (Burbidge & Gray 1970; Gilmour *et al.* 1987; NCDC 1984; NCDC 1988; National Capital Planning Authority 1992). A fifth, *Cheiranthra cyanea*, was recorded as occurring at Mulligans Flat by Burbidge & Gray (1970), Frawley (1991) and NCDC (1988a), but was not located during this study (or in recent survey work by M.S. Davis). It is very inconspicuous when not in flower, and may well have been overlooked; it is known to occur on the Gundaroo road verge in N.S.W. approximately 1.5 km to the north-east of the study area, and is fairly common in the Gunning and Yass districts, approximately 30 km to the north (B.J. Lepschi unpubl.).

Two introduced herbs, **Linum trigynum* and **Logfia gallica* are of regional significance. **Linum trigynum* (Lepschi & Davis 918 (AD, BRI, CANB, CHR, HO, K, MEL, NSW)) does not appear to have been previously recorded for the A.C.T. or the southern tablelands of N.S.W. (Gardner 1992), although it has since (early 1993) been collected at a few other sites in the Canberra-Queanbeyan area (B.J. Lepschi unpubl.). **Logfia gallica* (Lepschi 866, Lepschi & Davis 919 (both CANB, MEL, NSW)) represents a new record for both the A.C.T. and N.S.W. (Brown 1992).

Introduced species comprise 34% (93 spp; #*Acacia baileyana* is here regarded as introduced) of the 276 species recorded from Mulligans Flat; they occur throughout the area, but are most prevalent in the woodland and grassland formations, which have been subject to greater disturbance than the open forest areas. Grossly disturbed sites such as the Gundaroo road verge, the area around the shearing shed, the old school site and the verges of the vehicle tracks are particularly heavily invaded, with major weed species such as **Marrubium vulgare*, **Echium plantagineum*, and **Chondrilla juncea* largely confined to these sites at present.

**Rosa rubiginosa* is the only woody weed of any importance in the area, with other potentially invasive species (e.g.: **Crataegus monogyna*, **Pyracantha angustifolia* and #*Acacia baileyana*) currently of limited distribution and abundance.

Of the ornamental plantings on the old Mulligans Flat School site, only two species, **Pinus radiata* and #*Acacia baileyana* show signs of spreading. **P. radiata* is present as scattered small plants and seedlings, mainly in the vicinity of the parent plants, while *A. baileyana* occurs predominantly as mature plants in a few localities within the study area.

Mulligans Flat is an area of great conservation significance; low altitude woodland and grassland communities are very poorly represented in conservation reserves within the ACT and surrounding areas. Those that have been reserved are predominantly in the southern part of the Canberra area (lowland communities do not extend far beyond the current southern edge of Canberra), and Mulligans Flat represents the northernmost reservation of these communities in the ACT. It is also the

only reserve of any substantial size in the Gungahlin area of Canberra.

The relatively light clearing and grazing activity on Mulligans Flat has resulted in some of the best preserved areas of lowland open-forest, woodland and grassland in the ACT, which apart from their botanical importance also provide valuable habitat for a diverse vertebrate fauna (Frawley 1991; Taylor & Canberra Ornithologists Group 1992; W.S. Osborne pers. comm.).

Acknowledgments

Lyn Craven, Maxine Davis, Frank Ingwersen and Will Osborne all commented on the manuscript; Maxine kindly made available her unpublished survey data for the Mulligans Flat area and provided information for the preparation of Figure 2. Will also drew the draft for the figures and provided much appreciated encouragement and assistance.

References

- Anderberg, A.A. (1991). Taxonomy and phylogeny of the the tribe Gnaphalieae (Asteraceae). *Opera Botanica*. 104 : 1–195.
- Briggs, B.G., Carolin, R.C. & Pulley, J.M. (1977). Plantaginaceae. *Flora of New South Wales* 181:1–35.
- Brooker, M.I.H. & Kleinig, D.A. (1990). *Field Guide to Eucalypts, Vol. 1. South Eastern Australia*. (Inkata Press: Melbourne).
- Brown, E.A. (1992). Asteraceae. In Harden (1992): 131–341.
- Burbidge, N.T. & Gray, M. (1970). *Flora of the A.C.T.* (Australian National University Press: Canberra.)
- Carolin, R. (1992). *Goodenia*. *Flora of Australia* 35: 147–281
- Conn, B.J. (1992) *Oxalis*. In Harden (1992): 17–22
- Cooke, D.A. (1986). Iridaceae. *Flora of Australia* 46: 1–66.
- Crisp, M.D. (1991). Contributions towards a revision of *Daviesia* Smith (Fabaceae: Mirbelieae). II. The *D. latifolia* group. *Australian Systematic Botany*, 4: 229–298.
- Everett, J. (1992) *Gnaphalium*. In Harden (1992): 206–210.
- Everett, J. & Doust, A.N.L. (1992) *Craspedia*. In Harden (1992): 221–226.
- Frawley, K.J. (1991). *The Conservation of Remnant Woodland and Native Grassland in the A.C.T.* (National Parks Association of the A.C.T. (Inc.): Canberra.)
- Gardner, C.L. (1992). *Linum*. In Harden (1992): 16–17.
- Gilmour, P.M., Helman, C.E. & Osborne, W.S. (1987). *An Ecological Survey of the Mount Tennent – Blue Gum Creek Area, A.C.T.* Unpublished report to Conservation Council of the South East Region and Canberra.
- Gray, M. & McKee, H.S. (1969). *A List of Vascular Plants Occurring on Black Mountain and Environs, Canberra, A.C.T.* CSIRO Division of Plant Industry Technical Paper no 26.
- Gunn, R.H., Story, R., Galloway, R.W., Duffy, P.J.B., Yapp, G.A. & McAlpine, J.R. (1969). Lands of the Queanbeyan – Shoalhaven area, A.C.T. and N.S.W. *Land Research Series*. No. 24. (CSIRO, Melbourne.)
- Harden, G. J.(ed) (1990). *Flora of New South Wales*. Vol. 1 (NSW University Press: Sydney.)
- Harden, G.J (ed) (1991) *Flora of New South Wales* Vol. 2 (NSW University Press: Sydney.)
- Harden, G.J (ed) (1992) *Flora of New South Wales* Vol. 3 (NSW University Press: Sydney.)
- Harden, G.J (ed) in press (199–) *Flora of New South Wales* Vol. 4 (NSW University Press: Sydney.)
- Harden, G.J. & Rodd, A.N. (1990a). Rosaceae s. str. In Harden (1990): 528–541.
- Harden, G.J. & Rodd, A.N. (1990b). Malaceae. In Harden (1990): 542–547.
- Helman, C.E., Gilmour, P.M., Osborne, W.S. & Green, K. (1988). *An Ecological Survey of the Upper Cotter Catchment Wilderness Area, Namadgi National Park, A.C.T.* Unpublished report to Conservation Council of the South East Region and Canberra.

- Hill, K. & Johnson, L.A.S. (1991). Systematic studies in the eucalypts, 3. New taxa and combinations in *Eucalyptus* (Myrtaceae). *Telopea*, 4 : 223–268.
- Hnatiuk, R.J. (1990). *Census of Australian Vascular Plants*. (Australian Government Publishing Service: Canberra.)
- Ingwersen, F., Evans, O & Griffiths, B. (1974). *Vegetation of the Ainslie–Majura Reserve*. Conservation Series no 2. Department of the Capital Territory.
- Jacobs, S.W.L. (1990). Papaveraceae. In Harden (1990): 169–172.
- Jacobs, S.W.L. in prep. In Harden (199–).
- Jacobs, S.W.L. & Lapinuro, L. (1990). Amaranthaceae. In Harden (1990): 248–260.
- James, T.A. (1990). Violaceae. In Harden (1990): 435–441.
- James, T.A. & Harden, G.J. (1990). Euphorbiaceae. In Harden (1990): 389–430.
- Lee, A.T. and Macfarlane, T.D. (1986). *Lomandra*. *Flora of Australia* 46: 1–65.
- Makinson, R.O. (1990). Primulaceae. In Harden (1990): 504–506.
- National Capital Development Commission. (1984) *The Ecological Resources of the ACT*. National Capital Development Commission Technical Paper no. 42.
- (1988a). *Gungahlin: Environmental Impact Statement: Draft for Discussion*. (National Capital Development Commission: Canberra.)
- (1988b). *Sites of Significance in the ACT, volumes 1-7*, National Capital Development Commission Technical Paper no 56.
- National Capital Planning Authority. (1989) *Sites of significance in the ACT, volume 8*. National Capital Planning Authority Technical Paper no 56.
- (1992) *Sites of Significance in the ACT, volume 9*. National Capital Planning Authority Technical Paper no 56.
- Powell, J.M. & Wiecek, B.M. (1992). *Eryngium*. In Harden (1992): 91–92.
- Simon, B.K. (1992). A revision of the genus *Aristida* (Poaceae) in Australia *Australian Systematic Botany* 5: 129–226.
- Taylor, I.M. & Canberra Ornithologists Group. (1992) *Birds of the ACT: an Atlas*. (Canberra Ornithologists Group and National Capital Planning Authority: Canberra.)
- West, J.G. (1990). Portulacaceae. In Harden (1990): 178–185.
- Weston, P.H. (1991a). *Medicago*. In Harden (1991): 452–455.
- Weston, P.H. (1991b). *Pultenaea*. In Harden (1991): 481–497.
- Wilson, K.L. in prep. In Harden (199–).
- Wilson, P.G. (1990). Ophioglossaceae. In Harden (1990): 17–18.

Manuscript received 10 August 1992

Manuscript accepted 24 March 1993

Floristic lists of New South Wales (IV)

D.H. Benson and S.C. Melrose

Abstract

Benson, D.H. & Melrose, S.C. (*National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, NSW, Australia* 2000) 1993. *Floristic lists of New South Wales (IV)*. *Cunninghamia* 3 (1): 167–213. An annotated bibliography of 202 floristic lists mainly from the 1986–1992 period, has been collated. The bibliography continues the format of earlier listings, with notes on the locality (including 1:250 000 map sheet and additional Local Government Area occurrence), extent of species list and ecological information. Papers are numbered and ordered according to the botanical subdivisions of New South Wales, authors and dates of compilation.

Introduction

Floristic lists are often the only source of botanical information for a particular area and may serve as a useful starting point for more detailed study. Such lists may be used for general comparisons of the vegetation of different localities, or that of the same locality at different times. The preparation of an increasing number of environmental impact studies and plans of management in recent years has prompted a corresponding interest in floristic lists. This, the fourth annotated bibliography compiled by the Royal Botanic Gardens, follows the works of Pickard (1972); Bryant & Benson (1981) and Keith (1988), bringing the total of references in the series to 572.

Types of lists included

Similar criteria to those of the earlier bibliographies have been adopted and the journals listed by Bryant & Benson (1981) have been scanned. Most lists are from the 1986–1992 period, though a number of older, previously overlooked lists have been included. The lists range from regional floras to brief lists of predominating species and may or may not include ecological notes on the vegetation, the environment or the abundance of the species. They also vary considerably with regard to the size of the area surveyed and the precision with which this is defined, as well as completeness and the reliability of identifications. Nomenclature may be out of date, depending on when the lists were compiled.

The bibliography includes both published and unpublished material, copies of the latter being held at the Royal Botanic Gardens Library and available on request from the librarian.

Arrangement of the bibliography

As in Keith (1988), the lists are arranged according to the botanical subdivision in which they occur. A map of the botanical subdivisions of New South Wales is provided in the end papers. These are explained in full by Anderson (1961). Where a list covers more than one botanical subdivision it is listed under the major subdivision and cross-referenced in other relevant subdivisions. Within the subdivisions the lists

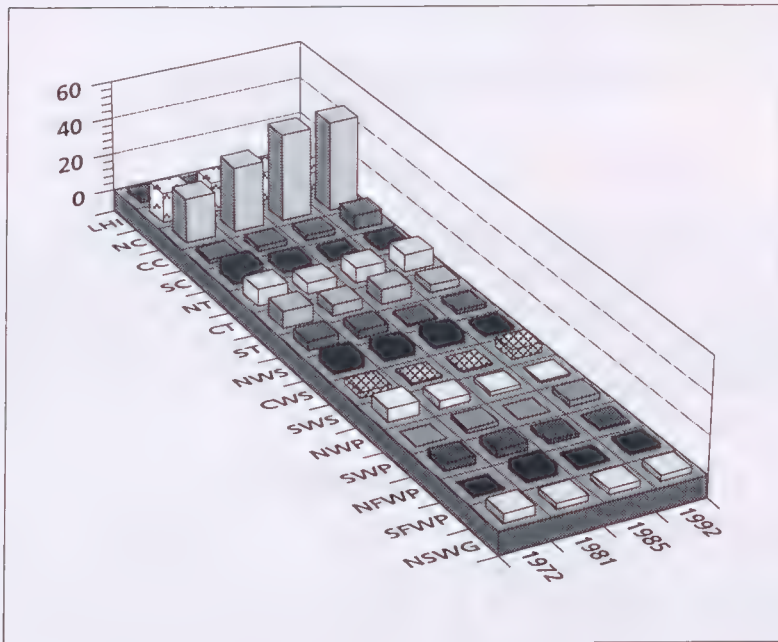


Figure 1. Changes in percentage of floristic lists for botanical subdivisions for bibliographies since 1972. See table 1 for figures.

Table 1. Percentage of floristic lists for each of the botanical subdivisions of N.S.W. Data from Pickard (1972), Bryant & Benson (1981), Keith (1988,) and this paper.

	1972	1981	1985	1993
Lord Howe Island	2	1	3	0
North Coast	16	16	15	9
Central Coast	24	35	47	49
South Coast	2	3	3	8
Northern Tablelands	8	4	2	3
Central Tablelands	9	6	8	9
Southern Tablelands	9	6	8	4
North Western Slopes	5	4	1	2
Central Western Slopes	6	5	5	2
South Western Slopes	3	1	1	5
North Western Plains	7	4	2	1
South Western Plains	0	2	0	3
North Far Western Plains	4	4	2	2
South Far Western Plains	0	5	1	2
New South Wales – General	5	3	3	3
Total %	100	99	101	100
Total number of lists	290	182	219	173

are arranged alphabetically by author and then by date. This arrangement is intended to facilitate searching by the geographical area of interest. As a further spacial index, the name(s) of the relevant 1:250 000 map sheet(s) and Local Government Areas (LGA) are given at the end of each reference. The numbering of references follows on from Keith (1988). Table 1 shows reference numbers for each of the botanical subdivisions.

Each entry in the bibliography is listed with its author, its date of publication, or compilation if unpublished, and its title. Annotations include the approximate number of species, their arrangement in the list and references to any ecological notes provided on abundance, habitat, soil type, plant communities, etc.

The list of 202 references is given below.

Results

There are 202 floristic lists in the current bibliography, in line with the earlier bibliographies (Table 1). The annual rate of accumulation of lists for 1986–1992 (7 years: 29/year) is down on the 1981–1985 period (5 years: 44/year) but up on the 1972–1981 period (9 years: 20/year).

The proportions of lists for the various botanical subdivisions (Figure 1, Table 1) show an increase in the percentage from the South Western Slopes and the South Coast, both areas needing further botanical documentation, but a decrease in the proportion from the North Coast. There is relatively little change for the other subdivisions. The majority of lists are still from the Central Coast (48%), reflecting the continuing interest in Sydney's urban bushland, and it is disappointing to see the very low numbers of lists presently available for other subdivisions particularly on the Western Slopes and Plains. This may not, however be a complete picture of the amount of work being done in these areas, as there are currently a number of major surveys, e.g., by the National Parks and Wildlife Service, amassing large databases from extensive site data that is never published. Hopefully this data will eventually become available, but until then, published lists will remain the main source of data to many workers.

Access to species list data is important to those involved in natural area management, and we urge people with lists that they would like included in forthcoming bibliographies to forward them to the Ecology Section. Unpublished lists will be lodged in the Royal Botanic Gardens Library and made available on request. In compiling lists for such purposes, accurate identifications and site localities are essential. Long, unannotated lists covering large, poorly defined areas are less useful. Such lists should be recorded either by sites or by plant communities and should be accompanied, where possible, by descriptions of the relevant plant communities, together with accurate locational information. Data on the relative abundance of the different species may also be worthwhile. There is also an increasing need for ecological observations on species, such as fire responses, fruiting periods, seed dispersal and growing periods. Such observations can be readily integrated with a species list.

General references

- Anderson, R.H. (1961) Flora of New South Wales. Introduction. *Contributions from the New South Wales National Herbarium Flora Series*, Nos 1–18: 1–15.
- Bryant, H.J. & Benson, D.H. (1981) Recent floristic lists of New South Wales. *Cunninghamia* 1(1): 59–77.
- Keith, D.A. (1988) Floristic lists of New South Wales (III). *Cunninghamia* 2(1): 39–73.
- Pickard, J. (1972) Annotated bibliography of floristic lists of New South Wales. *Contributions from the New South Wales National Herbarium* 4: 291–317.

Journals searched

The following journals were searched, together with a number of occasional publications for the period 1986 to 1992.

Australian Journal of Botany

Australian Journal of Ecology

Australian Journal of Marine & Freshwater Research

Australian Natural History

Australian Plants

Cunninghamia

Ecological Monographs

Ecology

ECOS

Forestry Commission NSW Research Notes

Journal of Ecology

Journal of Soil Conservation NSW

National Parks Journal (National Parks Association of NSW)

Proceedings of the Linnean Society of NSW

Telopea

The Victorian Naturalist

The Orchadian

Wetlands (Australia)

Floristic lists of New South Wales (IV)

LORD HOWE ISLAND

Nil

NORTH COAST

370 BENSON, J.S. (1981)

Tomaree National Park proposal

NSW National Parks & Wildlife Service (unpub.)

Discussion of land use and vegetation. Floristic lists for Tomaree Head and Morna Point, and Yaccaba Head rainforest (compiled by M. Dodkin and A. Clough).

1:250 000 topographic map: Newcastle

LGA: Port Stephens

371 BENSON, J.S. (1982)

Jasper Nature Reserve proposal

NSW National Parks & Wildlife Service (unpub.)

Discussion of riverfront vegetation including floristic list.

1:250 000 topographic map: Hastings

LGA: Hastings

- 372 BENSON, J.S. (1985)
Watchinbark Creek Nature Reserve proposal
NSW National Parks & Wildlife Service (unpub.)
Discussion of serpentinite vegetation including floristic list.
1:250 000 topographic map: Hastings
LGA: Gloucester
- 373 BENSON, J.S. (1986)
Proposed Timbarra River National Park
NSW National Parks & Wildlife Service (unpub.)
Vegetation and fauna described. Floristic list included.
1:250 000 topographic map: Warwick
LGA: Casino
- 374 BENSON, J.S. & HAGER, T. (1993)
The distribution and habitat of *Eucalyptus dunnii* (Myrtaceae) (Dunn's White Gum) in New South Wales.
Cunninghamia 3(1): 123–145
Survey of rare tree species including list of associated species
1:250 000 topographic map: Dorrigo, Warwick
LGA: Coffs Harbour, Nymboida, Kyogle
- 375 CRAWFORD, I. (1992)
The vegetation of the Singleton Army Area, November–December 1991
Prepared for CSIRO Division of Water Resources (unpub.)
Describes vegetation in terms of grassed areas, Forest Red Gum woodland remnants, Swamp Oak riverine forest, and Spotted Gum – Ironbark open forest. Lists about 250 species, both native and exotic, community recorded and voucher specimen numbers. Area is about 120 square km. south of Singleton between Wittingham and the Broken Back Range.
1:250 000 topographic map: Singleton
LGA: Singleton
- 376 FORESTRY COMMISSION (1990)
Flora species of the Bulahdelah Management Area
Pacific Highway (State Highway No.10) Bulahdelah-Coolongolook Deviation: Environmental Impact Statement Working Papers (Roads and Traffic Authority: Sydney)
Appendix A contains a list of 400 species in four communities in the Buladelah area: rainforest, wet sclerophyll forest, dry sclerophyll forest, and woodland/shrubland.
1:250 000 topographic map: Newcastle
LGA: Great Lakes

- 377 FOX, M.D. (1986)
 The effect of fire frequency on the structure and floristic composition of a wood land understory
Australian Journal of Ecology 11(1): 77-85
 The study showed that obligate seedling regenerators may be lost in frequently burnt areas, while vegetative regenerators and short lived obligate seedling regenerators may be lost in infrequently burnt areas. Thirty-eight understory species are listed with the mode of regeneration after fire.
 1:250 000 topographic map: Newcastle
 LGA: Port Stephens
- 378 GRIFFITH, S.J. (1989)
 Rainforest vegetation within and about Woko National Park and Camel's Hump Nature Reserve
 Prepared for N.S.W. National Parks & Wildlife Service (unpub.)
 Describes rainforest vegetation in the area and its conservation status. Appendices list over 300 rainforest species with abundance measures for 48 sites, site and inspection point data, and species and subspecies at their known southern limit of distribution in the North Coast botanical subdivision.
 1:250 000 topographic map: Hastings
 LGA: Gloucester
- 379 GRIFFITH, S.J. (1992)
 Vegetation of Crowdy Bay National Park
 NSW National Parks & Wildlife Service (draft report)
 Detailed vegetation descriptions with vegetation map (1:12 500) and discussion of significant species and vegetation management. List of 500 native species in part B.
 1:250 000 topographic map: Hastings
 LGA: Hastings
- 380 HUNTER REGION BOTANIC GARDENS LTD (1986)
 The Hunter Region Botanic Gardens Management Plan
 The Hunter Region Botanic Gardens Ltd.
 A listing of 300 species by family occurring naturally on or near site. Common names included.
 1:250 000 topographic map: Newcastle
 LGA: Newcastle
- 381 NEW SOUTH WALES DEPARTMENT OF PLANNING AND ENVIRONMENT
 Macleay - Apsley Land Use Study
 NSW National Parks & Wildlife Service submission (unpub.)
 Major report of area now Oxley Wild Rivers National Park. List of 800 vascular plant species provided based on 200 sampling sites. Land systems mapped.
 1:250 000 topographic map: Dorrig
 LGA: Dumaresq, Walcha

- 382 PENMAN, S., RANKIN, E., & MOYE, J. (1987)
Rare and endangered native orchid species survey
The Orchadian 9(1): 5–9
Lists 47 species and the degree of rarity and their location. Map of sites in the drainage basin of the Richmond River.
1:250 000 topographic map: Tweed Heads, Warwick, Maclean
LGA: Richmond River, Kyogle, Tweed
- 383 PRESSEY, R.L. & GRIFFITH, S.J. (1987)
Coastal wetlands and associated communities Tweed Shire, Northern New South Wales
NSW National Parks and Wildlife Service (unpub.)
A systematic listing of 768 species. Growth form is designated as are the communities in which the species are found.
1:250 000 topographic map: Tweed Heads
LGA: Tweed
- 384 PRESSEY, R.L. (1989)
Wetlands of the Lower Clarence Floodplain, Northern Coastal New South Wales
Proceedings of the Linnean Society of New South Wales 111(3): 143–155
List of 70 plants. Includes occurrence in open water wetlands by the number occurring, percent total number, total area occupied and percent of total wetland area.
1:250 000 topographic map: Grafton
LGA: Copmanhurst
- 385 PRESSEY, R.L. (1989)
Wetlands of the Lower Macleay Floodplain, Northern Coastal New South Wales
Proceedings of the Linnean Society of New South Wales 111(3): 157–168
Lists 118 plants with occurrence in open water wetlands, by number occurring, percent total number, total area occupied and percent of total wetland area.
1:250 000 topographic map: Dorrigo, Hastings, Coffs Harbour
LGA: Kempsey
- 386 RAINFOREST CONSERVATION SOCIETY INC (1992)
The Central Eastern Rainforests of Australia
World Heritage Nomination (draft)
Describes rainforest lands proposed for world heritage listing in N.S.W. and Queensland with sections on geology and geomorphology, soils, climate, bioclimates, vegetation, flora and fauna, with detailed justification for world heritage listing in terms of scientific values. Includes list of rare plant species, together with list of about 1700 native vascular plant species indicating occurrence at each of the nominated sites which include Border Ranges National Park, Limpinwood Nature Reserve, Numinbah N.R., Mt Warning N.P., Nightcap N.P., Mt Nothofagus F.R., Iluka N.R., Washpool N.P., Gibraltar Range N.P.,

Dorrigo N.P., New England N.P., Mt Hyland N.R., Werrikimbe N.P., Mt Sea-view N.R., Banda Banda Flora Reserve, Barrington Tops N.P.

1:250 000 topographic map: Tweed Heads, Warwick, Grafton, Maclean, Torrigo, Hastings, Tamworth, Newcastle

LGA: Kempsey, Kyogle, Tweed, Byron, Copmanhurst, Maclean, Nymboida, Tenterfield, Severn, Bellingen, Coffs Harbour, Walcha, Dungog, Gloucester, Singleton, Scone, Kempsey, Lismore, Hastings

- 387 SMITH, P., BENSON, J.S., DICK, R., DODKIN, M & ANDREW, D. (1984)

Proposed Mount Neville Nature Reserve

NSW National Parks & Wildlife Service (unpub.)

Plant communities described with vegetation map (1:25 000).

1:250 000 topographic map: Grafton

LGA: Casino

- 388 WILLIAMS, G. (1990)

Riverine rainforest remnants in the Manning valley

Wetlands (Australia) 9(2): 68-75

Describes three previously unrecognised riverine rainforest remnants with list of tree species and comparisons with lists for Wingham and Coocumbac Island Nature Reserves.

1:250 000 topographic map: Hastings

LGA: Greater Taree

- 389 WILLIAMS, G. & ADAM, P. (1991)

Rainforest remnants on headlands in the Manning Valley: their composition and conservation significance

Wetlands (Australia) 11(1): 21-30

A preliminary list of 94 native trees and shrubs within remnant rainforest communities is given for the headlands of Crowdy Head, Saltwater, Redhead, and Black Head.

1:250 000 topographic map: Hastings

LGA: Greater Taree

CENTRAL COAST

- 390 AKKERSDYK, P. (1985)

Plant list for Jannali Reserve

(unpub.)

A checklist of 222 plants found in the area.

1:250 000 topographic map: Wollongong

LGA: Sutherland

- 391 AKKERSDYK, P. (1989)
Kurnell Peninsula plant list
(unpub.)
Contains 340 species found in the area with common names. Includes a list of 66 weeds.
1:250 000 topographic map: Wollongong
LGA: Sutherland
- 392 ANON (1989)
Native species recorded in Sheldon Forest Turramurra
(unpub.)
An alphabetic listing of 86 species in the forest. Some have been examined for adaptations helpful in surviving drought and fire and results are noted.
1:250 000 topographic map: Sydney
LGA: Ku-ring-gai
- 393 ANON (no date)
Nepean Dam environmental survey – plant list (appendix 1)
Prepared for Water Board (unpub.)
List of 136 species by family indicating location on plateau, old spoil deposit or valley floor. Exotic species noted.
1:250 000 topographic map: Wollongong
LGA: Wollongong
- 394 ANON, (probably 1980s)
Species list of plants at Elizabeth Farm, Parramatta
Probably prepared for Historic Houses Trust (unpub.)
A checklist of 145 species and their location on the Farm. Map included. Gives a description of whether they occur as a bulb, tree, shrub, succulent, annual or perennial. Common names given.
1:250 000 topographic map: Sydney
LGA: Parramatta
- 395 ANOS – Warringah Inc.
The Native Orchids of Warringah Shire 1988–1989
NSW National Parks & Wildlife Service
A list of 57 terrestrial and 8 epiphytic orchids. Map and brief description of the area, vegetation and all orchids occurring in that area.
1:250 000 topographic map: Sydney
LGA: Warringah
- 396 BENSON, D.H. (1984)
List of plants growing on Bar Island, Hawkesbury River
Royal Botanic Gardens, Sydney (unpub.)

Listing of 100 species by family growing on Bar Island. Exotic species included.
1:250 000 topographic map: Sydney
LGA: Hornsby

397 BENSON, D.H. (1987)

Survey of vegetation associated with huts at Crater Cove, Dobroyd Head
Royal Botanic Gardens Sydney (unpub.)

An assessment of exotic species both naturalised and planted in relation to the huts and to the natural vegetation associated with the site. List of 50 exotic species recorded. Map included.

1:250 000 topographic map: Sydney

LGA: Manly

398 BENSON, D.H. (1989)

Native species recorded at Prospect Reservoir
Royal Botanic Gardens Sydney (unpub.)

List of 99 species. Rare species include: *Acacia pubescens*, *Pultenaea microphylla*, *Daviesia genistifolia*, *Lotus australis*, *Oxylobium scandens*, *Ranunculus inundatus*, *R. lappaceus*, *R. sessiliflorus* and *Scutellaria humilis*.

1:250 000 topographic map: Sydney

LGA: Blacktown Council

399 BENSON, D.H. (1989)

Natural bushland on Macquarie University Campus, North Ryde
Royal Botanic Gardens Sydney (unpub.)

A checklist of 95 species in this remnant Turpentine – Ironbark forest which is characteristic of shale areas in the Ryde area before industrial development.

1:250 000 topographic map: Sydney

LGA: Ryde

400 BENSON, D.H. (1989)

Native species recorded in Banksmeadow heath on sand dune at Banksmeadow Public School

Royal Botanic Gardens Sydney (unpub.)

This remnant of the Eastern Suburbs Banksia Scrub contains 20 indigenous species. The scrub once covered 7000 ha between Waterloo and Botany Bay. Recommendations for conservation are made.

1:250 000 topographic map: Sydney

LGA: Botany

401 BENSON, D.H. (1990)

Vegetation of the Driftway Reserve, Hawkesbury Campus, University of Western Sydney — an important remnant of floodplain forest and freshwater swamp
Royal Botanic Gardens Sydney (unpub.)

Description of two wetland areas and associated forest and recommending long term protection. List of about 150 native and exotic species indicating vegetation type, compiled from lists by Peter Lister and Erica Morris, L. McDougall and D. Benson, and J. Stricker. (see also Lister & Morris 1992)

1:250 000 topographic map: Sydney

LGA: Hawkesbury

402 BENSON, D.H. (1992)

Remnant native bushland at Campsie

Royal Botanic Gardens Sydney (unpub.)

Contains list of 42 species of native vegetation from remnant of Turpentine – Ironbark Forest on Wianamatta Shale soil. The site occupies 0.5 ha on the banks of the Cooks River at the end of Third Avenue.

1:250 000 topographic map: Sydney

LGA: Canterbury

403 BENSON, D.H. (1992)

The natural vegetation of the Penrith 1:100 000 map sheet

Cunninghamia 2(4): 541–596

Describes and maps 18 plant communities and discusses rare and endangered species, regional affinities and conservation of vegetation. Includes species lists for Grose Vale “limestone” and Native Vineyard, Cobbitty. For full species list for area see Benson & McDougall (1991).

1:250 000 topographic map: Sydney

LGA: Bankstown, Baulkham Hills, Blacktown, Blue Mountains, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta, Penrith, Wollondilly

404 BENSON, D. H., HOWELL, J. & McDOUGALL, L. (1989)

Vegetation of Big Bay Island, Marramarra Creek, Hawkesbury River, New South Wales

Royal Botanic Gardens, Sydney (unpub.)

A list of 88 species arranged alphabetically by family with seed dispersal mechanism noted. Notes on vegetation included. The island, unnamed but called Big Bay Island here, is part of Marramarra National Park.

1:250 000 topographic map: Sydney

LGA: Hornsby

405 BENSON, D. & HOWELL, J. (1990)

Taken for granted: the bushland of Sydney and its suburbs

Kangaroo Press: Kenthurst

This book describes eight main vegetation types in the County of Cumberland, their presettlement extent and the changes that have taken place since 1788. Includes lists of the common species of Sydney’s vegetation types.

1:250 000 topographic maps: Sydney, Wollongong

LGA: Ashfield, Auburn, Bankstown, Baulkham Hills, Blacktown, Botany, Burwood, Camden, Campbelltown, Canterbury, Concord, Drummoyne, Fairfield, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kogarah, Ku-ring-gai, Lane Cove, Leichhardt, Liverpool, Manly, Marrickville, Mosman, North Sydney, Parramatta, Penrith, Randwick, Rockdale, Ryde, South Sydney, Strathfield, Sutherland, Sydney City, Warringah, Waverley, Willoughby, Woollahra

406 BENSON, D.H. AND KEITH, D.A. (1990)

The natural vegetation of the Wallerawang 1: 100 000 map sheet

Cunninghamia 2(2): 305–335

The composition and extent of the present natural vegetation on the Wallerawang 1: 100 000 map sheet 8931 (lat. 30°00'–33°30'S, long. 150°00'–150°30'E) are described and mapped. There is a listing of 670 species by family, with a description of the community structure and associated environmental factors contained within 18 map units and 29 plant communities.

1:250 000 topographic map: Sydney

LGA: Greater Lithgow

407 BENSON, D.H., THOMAS, J. & BURKETT, J. (1990)

The natural vegetation of Bents Basin State Recreation Area

Cunninghamia 2(2): 223–262

Contains a systematic listing of 362 species found in the Bents Basin listed by the number of species found in 24 communities. Contains species of particular significance with notes on habitat/location, significance and potential threat. Also lists exotic species, their abundance and distribution.

1:250 000 topographic map: Sydney

LGA: Liverpool, Wollondilly

408 BENSON, D. & MCDUGALL, L. (1991)

Rare bushland plants of Western Sydney

Royal Botanic Gardens, Sydney

Describes c. 950 species of plants in the area with their occurrence in 5 major vegetation types with an estimate of abundance, their occurrence by local government area, and the conservation status of each species — whether conserved, vulnerable or extinct. 373 vulnerable species and 17 extinct species are listed.

1:250 000 topographic maps: Sydney, Wollongong

LGA: Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta, Penrith

409 BENSON, J.S. (1985)

Vegetation survey of Riverstone Meatworks property, South Windsor: vegetation remnant on Tertiary alluvium

NSW National Parks & Wildlife Service (unpub.)

Floristic lists and vegetation map for area now Windsor Downs Nature Reserve.

1:250 000 topographic map: Sydney

LGA: Blacktown, Hawkesbury

- 410 BROCKOFF, J.O., & ALLAWAY, W.G.(1989)
Vesicular-arbuscular mycorrhizal fungi in natural vegetation and sand-mined dunes at Bridge Hill, New South Wales
Wetlands (Australia) 8(2): 47–54-
Forty-seven of the 52 vascular species in both mined and unmined sites at Bridge Hill contained vesicular-arbuscular mycorrhizas. Bridge Hill is located in the Myall Lakes National Park (32°24'S, 152°30'E).
1:250 000 topographic map: Newcastle
LGA: Great Lakes
- 411 BUCHANAN, R.A. (1989)
Pied Currawongs (*Strepera graculina*): their diet and role in weed dispersal in suburban Sydney, New South Wales.
Proceedings of the Linnean Society of New South Wales 111: 241–255
Lists 46 species of seed found in the pellets regurgitated by pied currawongs from a garden in Thornleigh and the highest frequency in any one month. Commo names given as well as introduced species. Also lists additional fruits and seeds reported in previous studies which are additional to those recorded at Thornleigh.
1:250 000 topographic map: Sydney
LGA: Hornsby
- 412 CLARKE, P.J. & BENSON, D.H. (1986a)
Vegetation survey of Dharug National Park
Royal Botanic Gardens, Sydney (unpub.)
Contains vegetation analyses, descriptions, management and recommendations with listing of 700 species.
1:250 000 topographic map: Sydney
LGA: Gosford
- 413 CLARKE, P.J. & BENSON, D.H. (1986b)
Provisional floristic list for Wamberal Lagoon Nature Reserve
Royal Botanic Gardens, Sydney (unpub.)
Lists about 100 native and exotic species.
1:250 000 topographic map: Sydney
LGA: Gosford
- 414 CLARKE, P.J. & BENSON, D.H. (1987a)
Vegetation survey for proposed Nature Reserve at Mt. White – Mt Olive area
Royal Botanic Gardens, Sydney (unpub.)
Describes vegetation found on different geological units, with significant vegetation, plus rare and restricted species. Lists 450 species including rainforest species in the Gosford area with recommendations for management of the area.
1:250 000 topographic map: Sydney
LGA: Gosford

- 415 CLARKE, P.J. & BENSON, D.H. (1987b)
Vegetation survey of Lane Cove River State Recreation Area.
Royal Botanic Gardens, Sydney (unpub.)
Discusses the setting and vegetation patterns, types of species found in different landscape units, management and recommendations. Lists 351 species indigenous to the area and 133 weeds. Maps of vegetation & landscapes.
1:250 000 topographic map: Sydney
LGA: Lane Cove, Ryde, Hornsby
- 416 CLARKE, P.J. & BENSON, D.H. (1988)
The natural vegetation of Homebush Bay — two hundred years of changes.
Lists 64 species recorded in the estuarine wetlands at Homebush Bay and 105 species recorded in Eucalypt forest on Navy land at Silverwater.
Wetlands (Australia) 8(1): 3–15.
1:250 000 topographic map: Sydney
LGA: Auburn, Concord
- 417 COVENY, R.G. & McDOUGALL, L. (1990)
Plant species on Long Island Nature Reserve, Hawkesbury River
Royal Botanic Gardens, Sydney (unpub.)
Lists over 200 species from Long Island Nature Reserve near Brooklyn. Includes exotic species.
1:250 000 topographic map: Sydney
LGA: Hornsby
- 418 DARRACOT, J., McBARRON, E. & HATCH, M. (1987)
Yellow Rock, NSW, period 1920–1940
Shellharbour Municipal Library (unpub.)
Descriptive listing of many plant species growing at Yellow Rock near Albion Park in the period 1920–1940. Part of an historical account and includes references to fauna and flora both native and horticultural. Refer to species list in *Cunninghamia* (1981) 1(1): 59–71.
1:250 000 topographic map: Wollongong
LGA: Shellharbour
- 419 DODSON, J.R. (no date)
Widening of Forest Way vegetation survey: Ralston Ave to Mona Vale Road
Survey undertaken by Gunninah Consultants for Roads & Traffic Authority (unpub.)
List of 150 native species by family. Assesses natural vegetation in a 20m transect along Forest Way, Belrose for proposed widening of road. (See also Kodala 1990).
1:250 000 topographic map: Sydney
LGA: Warringah

420 DOLMAN, G.S. (1987)

Dynamics of Sydney's urban bushland from fine resolution pollen analysis
PhD Thesis, Australian National University (unpub.)

Contains a list of 300 species for the 48 ha recreation reserve surrounding Lake Parramatta (Lat. 33°47'30"S, Long. 151°00'30"E). Life forms, habitat types, and species presence during this survey and two previous surveys are noted. Exotics included.

1:250 000 topographic map: Sydney

LGA: Parramatta

421 FORD, A. (1989)

The sclerophyllous flora of Wollemi National Park
(unpub.)

An alphabetical checklist of 267 species from 4 localities in Wollemi National Park, Fern-tree gully, Mount Darcy, Mount Baker, and Dunns Swamp. Dunns Swamp listing includes two undescribed *Prostanthera* species.

1:250 000 topographic map: Singleton

LGA: Rylstone, Muswellbrook

422 FORD, A.J. (1990)

Flora list of the Bare Rock Bluff area, Wollemi National Park.
(unpub.)

List of 200 species from a single visit in February, 1990. The survey area is south of Bare Rock Bluff but not the Kekeelbon Mountains. Locality map. Coricudgy 1:25 000 map sheet.

1:250 000 topographic map: Singleton

LGA: Muswellbrook

423 FRIENDS OF BRADLEY BUSHLAND RESERVE (1990)

Draft plan of management for Bradley Bushland Reserve and Wildflower Walk, Mosman

Friends of Bradley Bushland Reserve, (unpub.)

This draft management plan includes appended species lists of 166 native plants and 100 exotic plants found in the Reserve. Map of the Reserve is included.

1:250 000 topographic map: Sydney

LGA: Mosman

424 GIBSON, C. (1992)

Prospect Reservoir native plant species list
(unpub.)

Contains 190 species listed by family. Site occurrence ratings, site conservation status, and regional conservation status are provided.

1:250 000 topographic map: Sydney

LGA: Blacktown

- 425 GIBSON, C. & MILLER, R. (1988)
Indigenous plant species list for Lansdowne Park
(unpub.)
Lists 158 plants growing in Lansdowne Park, Bankstown. Several species considered important because they are becoming rare. *Leichhardtia leptophylla* is considered very rare.
1:250 000 topographic sheet: Sydney
LGA: Bankstown
- 426 GIBSON, C. AND MILLER, R. (1988)
Species list for Norfolk Reserve and Lot 2, D.P. 546653, Greenacre
(unpub.)
List of 100 species by family.
1:250 000 topographic sheet: Sydney
LGA: Bankstown
- 427 GREENING AUSTRALIA URBAN BUSH MANAGEMENT UNIT (1991)
Baulkham Hills Shire bushland survey
Greening Australia: Sydney
List of trees and some groundcover species for parks in Castle Hill – Baulkham Hills area with recommendations on bushland management.
1:250 000 topographic sheet: Sydney
LGA: Baulkham Hills
- 428 HALL, A.R. (1989)
Native species at Malabar Bush (Anzac Rifle Range)
(unpub.)
An alphabetical listing of 200 species. Location according to eastern headland or western escarpment.
1:250 000 topographic map: Sydney
LGA: Randwick
- 429 JAMES, T.A. & KODELA, P.G. (1992)
Species list for Little Cattai Creek and tributary creeks
Royal Botanic Gardens, Sydney (unpub.)
List of about 200 native species for a relatively undisturbed sandstone area west of Maroota.
1:250 000 topographic map: Sydney
LGA: Baulkham Hills
- 430 KEITH, D. (1992)
List of vascular plants found at Caloola Pass
NSW National Parks & Wildlife Service (unpub.)

List of 60 native species found in layered tall mesic forest with *Eucalyptus fastigata* and *Eucalyptus smithii* on the escarpment talus slope

1:250 000 topographic map: Wollongong

LGA: Kiama

431 KODELA, P.G. (1990)

Widening of Forest Way vegetation survey: Hews Parade to Ralston Ave

Survey undertaken by Gunninah Consultants, for Roads & Traffic Authority (unpub.)

List of 170 species by family. Exotic species and noxious plants are noted. Assesses natural and planted vegetation in 20 m transect along Forest Way, Belrose for proposed widening of road. (See also Dodson undated).

1:250 000 topographic map: Sydney

LGA: Warringah

432 KODELA, P.G. & ROWE, R.R.M. (1990)

Survey of vegetation along New Line Road between Shepherds Drive and Purchase Road.

Survey undertaken by Gunninah Consultants, for Roads & Traffic Authority (unpub.)

Assesses remnant native vegetation on Wianamatta Shale and points out conservation and amenity significance. Lists 100 native and exotic species, basal area of large trees and species suitable for regeneration in the shale forest.

1:250 000 topographic map: Sydney

LGA: Hornsby

433 KUBIAK, P.J. (1989)

Floristic list of natural vegetation — Pages and Kittys Creeks, North Ryde. (unpub.)

Lists 260 species arranged alphabetically by family indicating presence on each creek.

1:250 000 topographic map: Sydney

LGA: Ryde

434 KUBIAK, P.J. (1990)

Endemic species of Lady Fuller Park in the Austinmer – Thirroul Area. (unpub.)

A list of 370 indigenous species with of location as to clifftops or below clifftops.

1:250 000 topographic map: Wollongong

LGA: Wollongong

435 KUBIAK, P.J. (1991)

Knapsack Creek area, Glenbrook — floristic list (excluding exotic species) (unpub.)

Lists 269 native species for the area bounded by Mitchells Pass Rd, the Great Western Highway, and Olivet and Barnet Sts. Some plants designated as apparently rare or uncommon in the area.

1:250 000 topographic map: Sydney

LGA: Blue Mountains

436 KUBIAK, P.J. (1992)

Middle Harbour catchment area — floristic list
(unpub.)

List of 560 naturally occurring native species from the Middle Harbour catchment, upstream of Spit Bridge. Species are listed by family and designated as widespread, occurring in scattered locations, apparently rare, apparently uncommon, or as garden escapees.

1:250 000 topographic map: Sydney

LGA: Willoughby, Warringah, Ku-ring-gai

437 KUBIAK, P.J. (1992b)

Narrabeen Lagoon catchment area — floristic list (excluding exotic species)
(unpub.)

Lists about 400 native species with brief comments on abundance.

1:250 000 topographic map: Sydney

LGA: Warringah

438 KUBIAK, P.J. (1993)

North Ryde Park, Cressy Rd, Pittwater Rd/Magdala Rd, North Ryde — floristic list (remnant native vegetation)
(unpub.)

Lists about 40 native species with brief comments on abundance and condition.

1:250 000 topographic map: Sydney

LGA: Ryde

439 KUBIAK, P.J. (1993b)

Dalrymple Hay Nature Reserve, Mona Vale Rd/Rosedale Rd, St Ives — floristic list (excluding exotic species)
(unpub.)

Lists about 120 native species with brief comments on rarity. 1:250 000 topographic map: Sydney

LGA: Ku-ring-gai

440 KUBIAK, P.J. (1993c)

Wallumatta Nature Reserve, Cressy Rd/Twin Rd, North Ryde — floristic list (excluding exotic species)
(unpub.)

Lists about 150 native species with brief comments on rarity.

1:250 000 topographic map: Sydney

LGA: Ryde

441 KUBIAK, P.J. (1993d)

Frenchs Forest Showground — Glen St/Pringle Ave/Blackbutts Rd, Frenchs Forest Ryde — floristic list (remnant native vegetation)

(unpub.)

Lists about 75 native species.

1:250 000 topographic map: Sydney

LGA: Warringah

442 LAI, M. (1991-2)

Plant species lists — Parsley Bay Reserve, Woollahra

(unpub.)

Includes separate lists of 100 native plant species (July 1991), and 100 exotic weed species with comments on removal (March 1992)

1:250 000 topographic map: Sydney

LGA: Woollahra

443 LEMBIT, R. (1985)

Vegetation survey — Prospect Creek

(Unpub.)

Includes list of 180 plants found within four sections extending from Widemere Rd. in the northwest to the Granville—Cabramatta railway line in the south-east. Common names and exotic species are included.

1:250 000 topographic map: Sydney

LGA: Fairfield

444 LEMBIT, R. (1987?)

Plant species from proposed extraction area at Menangle

(Unpub.)

Part of a flora and fauna study conducted by Mount King Ecological Surveys for the proposed sand and loam extraction works at Menangle Park. Table 1 contains a list of 120 plants present in forest or cleared habitats. Common names and exotic species are included.

1:250 000 topographic map: Wollongong

LGA: Wollondilly

445 LEMBIT, R. (no date)

Floristic list for selected cemeteries in the Penrith area

(Unpub.)

List of 120 species from St Thomas Church, Mulgoa; St Mary Magdalene Church, St Marys; and the Castlereagh General Cemetery. Exotic species are noted.

1:250 000 topographic map: Sydney
LGA: Penrith

- 446 LEMBIT, R. (no date)
Floristic list for proposed Phillip Parkway, Rooty Hill
(Unpub.)
Listing 100 plant species by family, exotic species noted.
1:250 000 topographic map: Sydney
LGA: Blacktown
- 447 LISTER, P.R. & MORRIS, E. (1990)
A census of the flora of the Hawkesbury Reserve
University of Western Sydney (unpub.)
A list of approximately 200 species including Bryophytes, ferns and angiosperms
for two portions of the Reserve, which is part of the Hawkesbury Campus of the
University. (See also Benson 1990)
1:250 000 topographic map: Sydney
LGA: Hawkesbury
- 448 McDOUGALL, L. & CONROY, R. (1989)
Preliminary checklist of plant species in Mitchell Park
(unpub.)
List of 260 species listed alphabetically by family. Introduced species noted.
Now part of Cattai National Park. Wilberforce 1:25 000 map sheet
1:250 000 topographic map: Sydney
LGA: Hawkesbury
- 449 McDOUGALL, L. & CONROY, R. (1988-1990)
Species list for Davidson Park State Recreation Area
Ku-ring-gai Chase National Park (unpub.)
Checklist of 450 species arranged alphabetically by family. Introduced species
indicated.
1:250 000 topographic map: Sydney
LGA: Ku-ring-gai, Warringah
- 450 McRAE, R.H.D. (1990)
Vegetation of Bouddi Peninsula, New South Wales
Cunninghamia 2(2): 263-293
Vegetation survey and map. Listing of 360 species with growth forms and vege-
tation areas types. Exotic species noted.
1:250 000 topographic map: Sydney
LGA: Gosford

- 451 MORRIS, E.C., SKELTON, N.J. & DURHAM, S.J. (1990)
Vegetation of three headlands of the Central Coast of New South Wales — Norah, Wamberal and Wybung Heads
Wetlands (Australia) 9(2): 49–67.
The vegetation of these headlands is described in terms of up to 12 vegetation types from closed-forest to *Themeda* grassland. Species, both native and exotic, are listed for each headland by vegetation type.
1:250 000 topographic map: Sydney
LGA: Wyong
- 452 NIEUWENHUIS, A. (1987)
The effect of fire frequency on the sclerophyll vegetation of the West Head, New South Wales
Australian Journal of Ecology 12(4): 373–385
Fifteen pairs of sites at West Head were assessed to research the effect of fire frequency on the relative abundance of obligate-seeders and vegetative-regenerators. An appended species list of 92 plants for each pair of sites is included indicating whether they occurred in frequently burnt or infrequently burnt sites.
1:250 000 topographic map: Sydney
LGA: Warringah
- 453 PAYNE, R. (no date)
Species lists for Nunns Creek Gullies
(unpub.)
A systematic listing of 95 plants located in the Erina area (33°27'S, 151°23'E). Common names given. *Endiandra discolor*, *Parsonsia velutina*, *Ripogonum fawcettianum* and *Calanthe triplecata* are found in the area and are species of special conservation significance to the area.
1:250 000 topographic map: Sydney
LGA: Gosford
- 454 PAYNE, R. (1988)
Provisional species list — Crommelin Native Arboretum, naturally occurring species (unpub.)
List of 160 species in two plant communities arranged by family. Introduced species and common names are noted (grasses not included). Located at Pearl Beach.
1:250 000 topographic map: Sydney
LGA: Gosford
- 455 PAYNE, R. (1988)
Vegetation report for a proposed sandstone extraction industry at Mount White. (unpub.)
Lists 260 species by plant community in a previously worked quarry which is

now a proposed sandstone extraction site. This listing is provisional due to the late winter timing of the survey. Probably representative of tree and shrub species but lacking in herbaceous and monocotyledonous species. Nature conservation capability assessment included which lists representativeness of vegetative community, rare or endangered species and disturbance. Topography, geology, soils, and hydrology of the area are described as is vegetation structure. Maps of the communities are included.

1:250 000 topographic map: Sydney

LGA: Gosford

456 PAYNE, R. (1989)

Vegetation report for Hallstrom Park (Flat Rock Reserve) Willoughby
Report No.2 (unpub.)

List of 128 species in the reserve. Map provided. Common names given. Some plants are marked as species of special significance in the area: *Platycerium bifurcatum*, *Asplenium australasicum*, *Austromyrtus tenuifolia*, *Leucopogon amplexicaule*.

1:250 000 topographic map: Sydney

LGA: Willoughby

457 PAYNE, R. (1989)

Vegetation assessment & strategy plan for reserve to be located on the Green Point Headland, Lake Macquarie
(unpub.)

Contains a species list of 286 plants with their location in 7 communities. Map included.

1:250 000 topographic map: Sydney

LGA: Lake Macquarie

458 PAYNE, R. (1989)

Melaleuca Swamp forest at Key Street, Toukley
Report prepared for Wyong Shire Council (unpub.)

List of 80 species occurring in a Melaleuca Swamp Open-forest on Quaternary alluvium with notes on structure, habitat and dominant species. Common names and introduced species noted. Faunal list included.

1:250 000 topographic map: Sydney

LGA: Wyong

459 PAYNE, R. (1989)

Species list of Ettymalong Swamp, Umina Beach, NSW.
(unpub.)

A list of 300 species with notes on vegetation structure, habitat, distribution and dominant species. Naturalised weeds along creek included (30% of species). Includes common names. Maps of rank weed growth & natural vegetation pockets. Ettymalong Swamp has been reclaimed with resultant flooding downstream.

Study undertaken to assess vegetation with view of widening the creek. Broken Bay 1:25 000 map sheet.

1:250 000 topographic map: Sydney

LGA: Gosford

460 PAYNE, R. (1989)

Botanical assessment of Porters Creek Swamp with relation to the urban release proposals of Wyong Shire
(unpub.)

Description of vegetation, topography, geology and soils. Includes a nature conservation capability assessment of the flora which lists representative species, rare and endangered plants and disturbances. 168 species listed by family. Introduced species indicated. Photos of vegetation communities and maps included.

1:250 000 topographic map: Sydney

LGA: Wyong

461 PAYNE, R. (1989)

Littoral rainforest on North Entrance Peninsula: extent of *Syzygium paniculatum*
(unpub.)

Lists 25 plants from remnant rainforest. Special reference to the extent of *Syzygium paniculatum*, *Ficus fraseri*, and *Euroschinus falcata*. Map and photographs.

1:250 000 topographic map: Sydney

LGA: Wyong

462 PAYNE, R. (1990)

A survey of three creeks in the Wadalba West catchment
(unpub.)

Includes 147 species in two plant communities. Exotic plants noted. Site map.

1:250 000 topographic map: Sydney

LGA: Wyong

463 PAYNE, R. (1990)

Vegetation survey for north-east by-pass road. Section: Etna Street to Bradys Gully Road, Alignment no 1. Report no 2.
(unpub.)

List of 140 species for open-forest on Terrigal Formation geology near Gosford. Introduced species and common names included.

1:250 000 topographic map: Sydney

LGA: Gosford

464 PAYNE, R. (1990)

Vegetation survey for north-east by-pass road. Section: Lushington Street to Terama Place, Alignment no 4. Report no 3.
(unpub.)

List of about 200 species for three plant communities near Gosford: woodland on Hawkesbury Sandstone and forest, and open-forest on Terrigal Formation geology. Includes introduced species. Rare or significant plants are identified as are noxious plants.

1:250 000 topographic map: Sydney

LGA: Gosford

465 PAYNE, R. (1990)

Vegetation survey of the main Wedderburn Plateau and minor creek systems (unpub.)

Contains an appended species list of 230 plants found in three vegetation communities located within the Wedderburn Plateau incorporating Pheasants Creek and Georges River sub catchments. Introduced species noted and common names given. Map of area.

1:250 000 topographic map: Sydney

LGA: Campbelltown

466 PAYNE, R. (1990)

Species list for Eastern Creek (unpub.)

List of 90 plants found at Eastern Creek between the motorway and the water supply pipeline.

1:250 000 topographic map: Sydney

LGA: Blacktown

467 PAYNE, R. (1991)

Flora and fauna survey: Bensville near Gosford, New South Wales (unpub.)

Contains 253 species in seven plant communities. Introduced species, and plants of special significance noted. Site map and plant community map.

1:250 000 topographic map: Sydney

LGA: Gosford

468 PAYNE, R. (1991)

Flora and fauna investigation at Yattalunga near Gosford, New South Wales (unpub.)

Includes 144 species of native and introduced species in four plant communities.

1:250 000 topographic map: Sydney

LGA: Gosford

469 PAYNE, R. (1991)

Botanical investigation of proposed upgrading of Wilfred Barrett Drive North Entrance Peninsula

(unpub.)

Contains 198 species in five plant communities. Includes exotic species. The endangered plant *Syzygium paniculatum* occurs in the area. Map.

1:250 000 topographic map: Sydney

LGA: Wyong

470 PAYNE, R. (1991)

Erina Valley flora and fauna survey
(unpub.)

134 species are contained in two plant communities in this area. Map.
Exotic species noted.

1:250 000 topographic map: Sydney

LGA: Gosford

471 PAYNE, R. (1992)

Enterprise Drive environmental study
(unpub.)

Includes list of 245 species found within three vegetation communities on two geological formations. Map.

1:250 000 topographic map: Sydney

LGA: Wyong

472 PAYNE, R. (1992)

Statement of environmental effects and landscape design report for a proposed paintball facility at Lot 4 DP773173 Bunning Creek Road
(Unpub.)

Plant species list contains 187 species which includes the rare, *Callistemon shires-sii*. Map.

1:250 000 topographic map: Sydney

LGA: Wyong

473 PERKINS, I. (1990)

Vegetation survey of Chullora Railway Workshops
(unpub.)

Lists 100 indigenous plant species located in the workshop area. The area contains remnant areas of natural vegetation typical of the Cumberland Plain vegetation associations.

1:250 000 topographic map: Sydney

LGA: Bankstown

474 ROSE, S. (1986)

A vegetation survey of the Nepean River near Menangle
Elizabeth Macarthur Agricultural Institute (unpub.)

Describes vegetation along the western bank of the River between Menangle Rd Crossing and Bergins Weir outlining significant species. Lists about 100 native species together with notes on occurrence. Also lists adjacent Orchard Paddock

exotic plantings.

1:250 000 topographic map: Wollongong

LGA: Camden

475 ROSE, S. (1990)

Elizabeth Macarthur Agricultural Institute Botanical Plant Collection (1985–1990)

Elizabeth Macarthur Agricultural Institute (unpub.)

Lists 600 species in the herbarium collection for specimens collected on the property, formerly part of Camden Park. Listings are by botanical and common name with family noted. Includes 248 species indigenous to the Institute grouped by growth form or habitat and 26 species found in lagoons and dams.

1:250 000 topographic map: Wollongong

LGA: Camden

476 S.G.A.P.(Society for Growing Australian Plants) Sutherland (1982)

Plant list Menai No.2 area

(unpub.)

Checklist of 178 species.

1:250 000 topographic map: Wollongong

LGA: Sutherland

477 S.G.A.P.(Society for Growing Australian Plants) Sutherland (1983)

Plant list, Towra Point

(unpub.)

A checklist of 200 species found in the area.

1:250 000 topographic map: Wollongong

LGA: Sutherland

478 SHERINGHAM, P.R., & SANDERS J.M. (1993)

Vegetation survey of Garigal National Park and surrounding Crown Lands

NSW National Parks & Wildlife Service report

Detailed vegetation survey describing and mapping (1:25 000) 21 plant communities and listing 300 indigenous plant species with notes on significant species and reserve management recommendations. Located near Narrabeen.

1:250 000 topographic map: Sydney

LGA: Warringah

479 SMITH, P. & SMITH, J. (1990)

Vegetation and fauna of Berowra Valley Bushland Park

Report prepared for Hornsby Shire Council

Describes 17 plant communities and lists over 500 native and exotic species with abundance and plant community. Discusses rare species and management considerations. Vegetation map and fauna lists.

1:250 000 topographic map: Sydney

LGA: Hornsby

- 480 STRICKER, J. (no date)
Interim list of plant species identified from Health Department land, Red Gum Avenue, Pennant Hills, N.S.W.
Nature Conservation Council of NSW (unpub.)
Lists 100 species with common names. Protected species noted. Divided into trees, shrubs and herbs.
1:250 000 topographic map: Sydney
LGA: Hornsby
- 481 SULMAN, F. (1914)
Excursions [to Glenbrook Creek]
Australian Naturalist 3:11
Brief list of the more notable species seen at Glenbrook Creek.
1:250 000 topographic map: Sydney
LGA: Blue Mountains
- 482 THOMAS, D (1990)
Rainforest conservation status in the Metropolitan and Woronora catchment areas
Water Board: Sydney
Describes rainforest in the catchment areas of Cataract, Cordeaux, Avon, Nepean and Woronora dams with detailed species lists for 31 sites.
1:250 000 topographic map: Wollongong
LGA: Wingecarribee, Wollondilly, Wollongong
- 483 THOMAS, J. & BENSON, D.H. (updated 1991)
Vegetation survey of Muogamarra Nature Reserve
Royal Botanic Gardens, Sydney (unpub.)
A reprinting with minor revisions including additions to the species list.
1:250 000 topographic map: Sydney
LGA: Hornsby
- 484 WINFIELD, D. (1991)
Mullet Creek report, appendices 1 and 2
Student exercise (unpub.)
Lists of 180 native and 50 exotic species for Mullet Creek, south of Ingleside Park, Warriewood.
1:250 000 topographic map: Sydney
LGA: Warringah
- 485 WINNING, G. (1990)
Lake Macquarie Natural Areas Study
(unpub.)
Contains descriptions of the plant communities, factors affecting distribution, significant flora and conservation. There is a vegetation map and a structural

classification of plant communities.
 1:250 000 topographic map: Sydney
 LGA: Lake Macquarie
SOUTH COAST

- 486 ALBRECHT, D. (1986a)
 Plant species growing in the vicinity of the summit of Mount Imlay
 Royal Botanic Gardens, Melbourne (unpub.)
 Alphabetical listing by family of 89 species, designated either east and south-east or west of the summit.
 1:250 000 topographic map: Mallacoota
 LGA: Bega Valley
- 487 ALBRECHT, D. (1986b)
 Vascular flora of Narrabarba Hill
 Royal Botanic Gardens, Melbourne (unpub.)
 93 species arranged alphabetically by family with location: vicinity, *Eucalyptus sieberi* forest or summit.
 East of Princes Highway, South of Wonboyn River. Eden 1:100 000 map sheet, grid ref. 518 719.
 1:250 000 topographic map: Mallacoota
 LGA: Bega Valley
- 488 ALBRECHT, D. (1986c)
 Vascular flora of the Nethercote Falls area, Nullica State Forest
 Royal Botanic Gardens, Melbourne (unpub.)
 260 species listed alphabetically by family.
 Nullica State Forest is above the Towamba River between Upper Kiah and Nethercote.
 1:250 000 topographic map: Mallacoota
 LGA: Bega Valley
- 489 BENSON, J.S., ANDREWS, D. & CAMPBELL, D. (1986)
 Cudmirrah sand dunes: report on flora and fauna
 NSW National Parks & Wildlife Service (unpub.)
 Floristic and faunal lists and vegetation description for area near Sussex Inlet.
 1:250 000 topographic map: Ulladulla
 LGA: Shoalhaven
- 490 BINNS, D. (1988)
 A preliminary list of vascular plant species for far south-eastern New South Wales
Forestry Commission of NSW research paper No 4
 Lists c. 1000 species of vascular plants in the Eden native forest management area by geographic distribution and provides a risk assessment, occurrence and

comments. Contains an appended list of species by site.

1:250 000 topographic maps: Bega, Mallacoota

LGA: Bega Valley

- 491 BINNS, D.L. & KAVANAGH, R.P. (1990a)

Flora and fauna survey of Nalbaugh State Forest (part), Bombala District, Eden Region, south-eastern New South Wales

Forest Resources Series No 9 (Forestry Commission of NSW: Sydney)

Detailed description of 20 vegetation communities with list of 265 native and five naturalised plant species.

1:250 000 topographic maps: Bega

LGA: Bombala

- 492 BINNS, D.L. & KAVANAGH, R.P. (1990b)

Flora and fauna survey, Nullica State Forest (part), Eden District, Eden Region, south-eastern New South Wales

Forest Resources Series No 10 (Forestry Commission of NSW: Sydney)

Detailed description of 27 vegetation communities with list of 370 native and nine naturalised plant species.

1:250 000 topographic maps: Bega

LGA: Bega Valley

- 493 CHIPPENDALE, G.M. (1991)

Broulee plants

Nature in Eurobodalla (Journal of the Eurobodalla Natural History Society) (4): 40–44

Describes the successional communities of Broulee with a list of 60 species designated for location on island, forest, dunes and beach.

1:250 000 topographic map: Ulladulla

LGA: Eurobodalla

- 494 CRAWFORD, I. (1992)

Plant list for Wadbilliga NP and the proposed Bemboka NP, May 1992 (unpub.)

This includes records from R. Outhred's survey of 215 sites in Wadbilliga National Park in 1984, from D. Keith's survey of 13 sites and 21 sites surveyed by I. Crawford (et al.) in 1992 in Wadbilliga and the proposed Bemboka National Park. List of about 500 native and exotic species.

1:250 000 topographic map: Bega

LGA: Bega Valley

- 495 DODSON, J.R., KODELA, P.G. & MYERS, C.A. (1988)

Vegetation survey of the Tantawanglo research catchments in the Eden Forestry Region, New South Wales

Forest Resources Series No 4, (Forestry Commission of NSW: Sydney)

Includes abundance data for species from 30 permanent plots (radius 20 m) in Glenbog State Forest including cover and basal area together with list of vascular species for the research catchments.

1:250 000 topographic maps: Bega

LGA: Bega Valley

496 FANNING, F.D. & FATCHEN, T.J. (1990)

The Upper Wog Wog River catchment of Coolangubra and Nalbaugh State Forest (Mines Road area) New South Wales; a flora and fauna survey

Forest Resources Series No 12 (Forestry Commission of NSW: Sydney)

Detailed description of vegetation recognising 14 types with list of 287 plant species including frequency over 113 sites.

1:250 000 topographic maps: Bega

LGA: Bega Valley

497 FANNING, F.D. & MILLS, K. (1990)

Flora and fauna survey of the Myanba Creek catchment, Coolangubra State Forest, Eden Region

Forest Resources Series No 11 (Forestry Commission of NSW: Sydney)

Detailed description of vegetation recognising 19 types with list of 338 plant species including frequency over 107 sites.

1:250 000 topographic maps: Bega

LGA: Bega Valley

498 FANNING, F.D. & MILLS, K. (1991)

The Stockyard Creek catchment of Coolangubra State Forest, New South Wales; a flora and fauna survey

Forest Resources Series No 13 (Forestry Commission of NSW: Sydney)

Detailed description of vegetation recognising 25 types with list of 280 plant species including frequency over 66 sites.

1:250 000 topographic maps: Bega

LGA: Bega Valley

499 KEITH, D.A. (1990)

Rare and biogeographically significant vascular plant species of the Eden Region, South-eastern New South Wales: a listing for the "fine-filter" approach. *Proceedings of the Linnean Society of N.S.W.* 112: 111-132.

Lists 13 species endemic to the region, 40 rare or threatened in an Australia-wide context, 34 uncommon throughout their distribution, 6 restricted outside the Eden region, 279 uncommon within the region but common elsewhere, 8 depleted in the wild, 183 reaching their geographical limit of distribution in the Eden region, 23 represented in the Eden region by geographically distinct populations, and 8 represented by ecologically disjunct populations. Locations and selection criteria included as well as a map of the area.

1:250 000 topographic map: Bega

LGA: Bega Valley, Cooma-Monaro, Bombala

500 KEITH, D. & ASHBY, E. (1992)

Vascular plants of conservation significance in the South East Forests of New South Wales

NSW National Parks & Wildlife Service Occasional Paper No 11

Lists vascular plant taxa of conservation significance in the South East Forest region extending east of Bombala from Bermagui to the Victorian border along the coast. 432 taxa are listed under various categories of rarity, biogeographic or ecological significance. Appendices contain a full account of distributional data gathered on each taxon from herbaria, vegetation survey literature and databases, taxonomic literature and botanists.

1:250 000 topographic map: Bega, Mallacoota

LGA: Bega Valley, Bombala

501 PAYNE, R. (1988)

Vegetation assessment for the proposed U.H.F. transmission station on Little Forest Plateau, Morton National Park
(unpub.)

Includes list of 220 plants from Little Forest Plateau. Map and photographs of communities included. Location of species in Woodland/Forest, Heathland/Sedgeland or Closed Forest is noted. 16 km south of Ulladulla

1:250 000 topographic map: Ulladulla

LGA: Shoalhaven

NORTHERN TABLELANDS

502 BENSON, J. (1992)

The distribution, abundance and conservation status of *Grevillea beadleana* (Proteaceae): an endangered species

Cunninghamia 2(4): 503–521

Includes a list of 130 species found in association with *G. beadleana* in Guy Fawkes National Park and at Binghi.

1:250 000 topographic map: Grafton, Dorrigo

LGA: Walcha, Dumaresq, Severn, Tenterfield, Nymboida

503 CURTIS, D. (1992)

Native trees and shrubs of the Northern Tablelands: the Armidale area, Dangarsleigh area, Uralla area and Wongwibinda area.(separate leaflets)

Greening Australia: Armidale

Lists of trees and shrubs for local regions with species listed by topographical position and underlying geology.

1:250 000 topographic map: Dorrigo, Manilla

LGA: Armidale, Dumaresq, Uralla

- 504 CURTIS, D., DAVIES, D., & LIND, J. (1992)
Native trees and shrubs of the Northern Tablelands of N.S.W. The Invergowrie area
Greening Australia Field Notes (Greening Australia: Armidale)
A list of trees and shrubs for 15 sites in the Armidale region with a listing of species associated by topographical position and underlying geology.
1:250 000 topographic map: Dorrigo
LGA: Dumaresq
- 505 CURTIS, D. & ROBINSON, G. (1992)
Native trees and shrubs of the Northern Tablelands: the Glen Innes area
Greening Australia: Armidale
Lists of trees and shrubs with species listed by topographical position and underlying geology.
1:250 000 topographic map: Grafton
LGA: Glen Innes
- 506 HOSKING, J. (1990)
Flora of Werrikimbe National Park
(unpub.)
A list of 430 species with common names. Includes introduced species. 66 km east of Walcha.
1:250 000 topographic map: Hastings
LGA: Walcha
- 507 ROBINSON, G.G. (about 1990)
A guide to eucalypts in the Glen Innes area
Glen Innes Natural Resource Advisory Committee
Describes over 30 common eucalypts of the area with information on their distribution and potential uses.
1:250 000 topographic map: Grafton
LGA: Glen Innes
- 508 ROGERS, R.W. & WHALLEY, R.D.B. (1989)
Relationship between diaspore characteristics and distribution of grasses around sheep camps on the Northern Tablelands of New South Wales
Australian Journal of Botany 37: 501-510
Twenty-seven species of grasses are listed according to association with sheep camps. Attributes described include length/breadth ratio for caryopsis, germination, life history and origin.
1:250 000 topographic map: Dorrigo
LGA: Dumaresq

CENTRAL TABLELANDS

- 509 BOWDEN, I. (1962)
Orchids of the Blue Mountains NSW
Australian Naturalist 12(3): 11–20
Orchids of the sandstone regions including the catchment of the Grose River and south to the Coxs River.
1:250 000 topographic map: Sydney
LGA: Blue Mountains
- 510 DOWNING, A.J., RAMSAY, H.P., & SCHOFIELD, W.B. (1991)
Bryophytes in the vicinity of Jenolan Caves, New South Wales
Cunninghamia 2(3): 371–384
Records 115 bryophytes including five new records of mosses for NSW and 18 additions to the mosses of the Central Tablelands.
1:250 000 topographic map: Sydney
LGA: Blue Mountains
- 511 FORD, A.J. (1990)
Flora list of Clandulla State Forest
(unpub.)
A one day survey listing 125 species by families. Locality map. Near Kandos.
1:250 000 topographic map: Singleton
LGA: Rylstone
- 512 GOODE, J. (1989)
Study of plant succession in the Blue Mountains
Student exercise (unpub.)
Transect through sedge swamp, sheltered gully and open-forest at Bullaburra near Minnatonka Falls describing vegetation and listing about 100 species.
1:250 000 topographic map: Sydney
LGA: Blue Mountains
- 513 HOLLAND, W.N. BENSON, D.H. & McRAE R.H.D. (1992)
Spatial and temporal variation in a perched headwater valley in the Blue Mountains: geology, geomorphology, vegetation, soils and hydrology
Proceedings of the Linnean Society of N.S.W. 113: 271–295.
Includes list of 100 species for perennial swamp, ephemeral swamp and wood land on sandstone near Leura.
1:250 000 topographic map: Sydney
LGA: Blue Mountains

- 514 INGRAM, C.K. (1987)
 Checklist of the vascular flora of Mount Tomah
The Mount Tomah Book. (The Mount Tomah Society and the Royal Botanic Gardens, Sydney): 63–85
 A checklist of 650 species (ferns, cycads and conifers, monocots and dicots). Also a checklist of reported occurrences in the area which includes 42 species. An historical account of the area with chapters on vegetation, insects, birds, fauna, geography and geology of the area.
 1:250 000 topographic map: Sydney
 LGA: Blue Mountains
- 515 KODELA, P.G. (1989)
 Vascular plant species list for Robertson Nature Reserve, Central Tablelands, NSW
 (unpub.)
 List of 60 species including introduced species.
 1:250 000 topographic map: Wollongong
 LGA: Wingecarribee
- 516 KODELA, P.G. (1990a)
 Robertson Plateau rainforest: remnants of the Yarrawa Brush
National Parks Journal 34(4): 28–31.
 Includes list of 100 species found in patches of Robertson rainforest. Listed by the headings of mosses, ferns, herbs, trees and shrubs and climbers. Map of present and former extent of Yarrawa Brush.
 1:250 000 topographic map: Wollongong
 LGA: Wingecarribee
- 517 KODELA, P.J. (1990b)
 Modern pollen rain from forest communities on the Robertson Plateau, New South Wales
Australian Journal of Botany 38: 1–24
 Rainforest, open to tall open-forest with mesic understorey, tall open-forest with predominantly sclerophyllous understorey and dry open to tall open-forest sites with minimal disturbance were sampled. The checklist of 200 species lists the percentage basal cover for arboreal species, and percentage foliage cover for other taxa.
 1:250 000 topographic map: Wollongong
 LGA: Wingecarribee
- 518 KODELA, P.G. (1992a)
 Native vegetation remnants and notes on some rare and locally significant plant species in the Robertson area New South Wales.
Eucryphia (Journal of the Robertson Environment Protection Society Inc) 6: 6–9
 Discusses the importance of vegetation remnants in the area with details of the

rare species *Eucalyptus macarthurii*, *Eucryphia moorei*, *Gentiana wingecarribiensis*, *Lilaeopsis polyantha* and *Livistona australis*

1:250 000 topographic map: Wollongong

LGA: Wingecarribee

519 KODELA, P.G. (1992b)

Plant species recorded from pastures, roadsides and wasteland areas in the Robertson, Moss Vale region, Central Tablelands.

(unpub.)

Lists by family 130 native and exotic species.

1:250 000 topographic map: Wollongong

LGA: Wingecarribee

520 KODELA, P.G. & HOPE, G.S (1992)

Wingecarribee Swamp: Statement of Significance

National Trust of Australia (New South Wales)

120 species are listed from this large montane peatland. The swamp contains the rare herb *Gentiana wingecarribiensis* and the rare orchid *Prasophyllum uroglossum*, both endemic to the site.

1:250 000 topographic map: Wollongong

LGA: Wingecarribee

521 KODELA, P.G., JAMES, T.A., COVENY, R.G., & HIND, P.D. (1992)

Reconnaissance survey of the vegetation at Long Swamp, near Penrose, Central Tablelands, N.S.W.

Royal Botanic Gardens Sydney (unpub.)

Includes list of 35 species recorded from Long Swamp from July–September, 1992. Another 33 species are recorded near the swamp margins and surrounding slopes and includes the rare and uncommon plants: *Eucalyptus macarthurii*, *Phyllota humifusa*, and the fern *Botrychium australe*.

1:250 000 topographic map: Wollongong

LGA: Wingecarribee

522 PORTER, C.L. (1992)

Distribution and abundance of *Blandfordia cunninghamii* Lindley (Blandfordiaceae) *Cunninghamia* 2(4): 523–532

Includes list of 70 species found in association with *Blandfordia* in the Blue Mountains.

1:250 000 topographic map: Sydney

LGA: Blue Mountains

523 PRATTEN, C. (1986)

A case for a further Flora Reserve within Mullions Range State Forest No 176. (unpub.)

The distribution and/or occurrence of *Eucalyptus radiata* ssp. *robertsonii*, *E. sparsifolia* and *Acacia boormanii* in the Mullions Range State Forest are discussed and a new Flora Reserve is recommended. An alphabetically arranged list of 139 plants growing in the Bosches Creek Flora Reserve and the study area is appended. Main text without species list published in *National Parks Journal* 30(6): 19–21.

1:250 000 topographic sheet: Bathurst

LGA: Cabonne

- 524 RAMSAY, H.P., DOWNING, A. & SCHOFIELD, W.B. (1990)

Bryophytes of Mount Tomah Botanic Garden

Cunninghamia 2(2): 295–303

A preliminary listing of 85 bryophytes found in the gardens and the rainforest area.

1:250 000 topographic map: Sydney

LGA: Blue Mountains

- 525 ROBERTSON ENVIRONMENT PROTECTION SOCIETY (1993)

A guide to the Yarra-ara Brush: trees, shrubs and vines of the Robertson rainforest remnants

The Robertson Environment Protection Society Inc.

Describes over 50 species found in patches of Robertson rainforest with map of rainforest remnants.

1:250 000 topographic map: Wollongong

LGA: Wingecarribee

- 526 STILES, A. (1991)

Checklist of vascular plants in Robertson rainforests

Eucryphia (Journal of the Robertson Environment Protection Society Inc) No.2, March.

List of 140 native species with common names.

1:250 000 topographic map: Wollongong

LGA: Wingecarribee

SOUTHERN TABLELANDS

- 527 ALBRECHT, D. (1987)

Preliminary checklist of the vascular plants of Nalbaugh National Park
Royal Botanic Gardens, Melbourne (unpub.)

Checklist of 382 species listed including introduced species.

Nalbaugh National Park is 26 km SE of Bombala.

1:250 000 topographic map: Bega

LGA: Bombala

- 528 BENSON, J.S. & WYSE JACKSON, M. (1993)
The native grasslands of the Monaro Region.
In McDougall, K. & Kirkpatrick, J.B. *Conservation of lowland native grasslands in south-eastern Australia* (Worldwide Fund for Nature: Sydney)
Survey of native grassland remnants between Canberra and Bombala including floristic lists, vegetation classification and key sites for conservation.
1:250 000 topographic map: Canberra, Bega
LGA: Queanbeyan, Cooma-Monaro, Snowy River, A.C.T.
- 529 CRAWFORD, I. (1988)
Bombala River plant collection
(unpub.)
An alphabetical listing by family of 200 species found within 1.1 km northwest of the confluence of the Bombala River and Back Creek. Description of the area with dominant tree species given. Vascular plants, lichens, liverworts & mosses included.
1:250 000 topographic map: Bega
LGA: Bombala
- 530 KODELA, P.G. & FOSTER, D.A. (1990)
Common plants and soil salinity in the Lower Boro area, Southern Tablelands, NSW
Cunninghamia 2(2): 217–222.
A list of 135 plant species that are found in the area. A habitat information coding is used to designate locations of the species.
1:250 000 topographic map: Canberra
LGA: Mulwaree
- 531 LEIGH, J.H., WIMBUSH, D.J., WOOD, D.H., HOLGATE, M.D., SLEE, A.V., STANGER, M.G., & FORRESTER, R.I. (1987)
Effects of rabbit grazing and fire on a subalpine environment
Australian Journal of Botany 35: 433–464
Contains a list of 188 species of vascular plants and one species of moss from the study site near Kiandra. Species are listed by life form. Individual species are described as is an historical perspective of the vegetation.
1:250 000 topographic map: Wagga Wagga
LGA: Snowy River
- 532 THOMAS, D. (1992)
Millended Springs vegetation survey
Water Board Catchment Services Unit: Sydney
Located 45 km south of Goulburn on the western side of the Tarago – Lower Boro Road, the survey includes a list of 125 species observed at ten sites.
Map included.
1:250 000 topographic map: Canberra
LGA: Goulburn

- 533 WHAITE, J. & O'NEILL, M. (1987)
An outline of the flora of the Goulburn district
Society for Growing Australian Plants, Canberra region Newsletter 7(6): 7-10.
Lists 400 species in alphabetical order by genus. Areas around Bungonia Gorge, Shoalhaven Gorge and Lake Bathurst described.
1:250 000 topographic map: Goulburn
LGA: Mulwaree

NORTH WESTERN SLOPES

- 534 BENSON, J. & ANDREW, D. (1990)
The flora, fauna and conservation significance of Ben Halls Gap State Forest, Nundle, NSW
Technical Report No. 90/1 (NSW National Parks & Wildlife Service)
An alphabetical list of 120 species by growth form and presence in plant associations in the area. Some bryophytes are included. Plant species of special significance discussed.
1:250 000 topographic map: Tamworth
LGA: Nundle
- 535 HOSKING, J. (1990a)
Flowering times of plants found in Oxley Park, Tamworth
Cunninghamia 2(2): 197-216
List of 434 plants and their flowering times. Addendum in *Cunninghamia* 2(3): 501.
1:250 000 topographic map: Tamworth
LGA: Parry
- 536 HOSKING, J. (1990b)
Flora of Warrabah National Park
(unpub.)
List of 400 species with common names including introduced species. 35 km N.E. of Manilla
1:250 000 topographic map: Manilla
LGA: Manilla
- 537 HOSKING, J. (1990c)
Flora of Attunga State Forest
(unpub.)
List of 313 species with authorities, common names and introduced species. Tamworth area.
1:250 000 topographic map: Manilla
LGA: Parry

- 538 INOUE, D.W. & PYKE, G.H. (1988)

Pollination biology in the Snowy Mountains of Australia: comparisons with montane Colorado, USA

Australian Journal of Ecology 13(2): 191–210

Aspects of pollination biology were examined in the Charlottes Pass area from Dec. 1983 – Mar. 1984 which included flowering phenology, corolla tube lengths, flower colour, ultraviolet reflectance patterns, visitation rates to the flowers and proboscis lengths of the flower-visiting insects. Forty-three species are listed with observation periods, visitation rates and flower visitors. Appendix contains 62 species with corolla length, flower colour, UV reflection and length of flowering period.

1:250 000 topographic map: Tallangatta

LGA: Snowy River

CENTRAL WESTERN SLOPES

- 539 TURNER, R.J. (1973)

Native plants from Kangaroooby

Forestry Office, Forbes (unpub.)

A checklist of 137 species, with common names, found in the Kangaroooby district (33°43'00"S 148°20' 00"E).

1:250 000 topographic map: Forbes

LGA: Weddin

- 540 ALTHOFER, G.W. & HARDEN, G.J. (1980)

The flora of Mt Arthur Reserve, Wellington, NSW.

Trustees of Mt Arthur Reserve: Wellington

A checklist of 530 species including bryophytes and lichens. Includes distribution and habitat. Location map.

1:250 000 topographic map: Dubbo

LGA: Wellington

- 541 LEPSCHI, B.J. (1989)

Preliminary floristic list for Cowal State & National Forest N.S.W. (unpub.)

List of 75 species including exotic species.

1:250 000 topographic map: Narromine

LGA: Narromine

- 542 TURNER, R.J. (1973)

Species list for Bumberry State Forest No. 891

Forestry Office, Forbes (unpub.)

List of 123 species. Located east of Parkes.

1:250 000 topographic map: Forbes
LGA: Parkes

See also SWS - Norris & Thomas (1991)

SOUTH WESTERN SLOPES

543 BURROWS, G.(1992a)

The Rock Nature Reserve: species list
Charles Sturt University – Riverina (unpub.)

List of about 220 species, both native and exotic, incorporating lists by J.H. Willis (1967–69), Willis, Johnston and Fleetwood (NSW National Parks & Wildlife Service), and G.Burrows (1987–90). Located 30 km southwest of Wagga.

1:250 000 topographic map: Wagga Wagga
LGA: Lockhart

544 BURROWS, G.(1992b)

Pomingalarna Reserve: species list
Charles Sturt University – Riverina (unpub.)

List of about 200 species, both native and exotic, incorporating lists by J. Webb and G.Burrows. Located 5 km west of Wagga.

1:250 000 topographic map: Wagga Wagga
LGA: Wagga Wagga

545 BURROWS, G.(1992c)

Plant species list for the Winery Hill — an area of remnant vegetation on the campus of Charles Sturt University – Riverina
Charles Sturt University – Riverina (unpub.)

List of 111 species, 50 native and 61 exotic. Located 5 km north of Wagga.

1:250 000 topographic map: Wagga Wagga
LGA: Wagga Wagga

546 BURROWS, G. (no date)

Flora of Mt Galore
Charles Sturt University – Riverina (unpub.)

List of about 100 species, both native and exotic, incorporating lists by J.H. Willis (1967) and J. Bladen et al (1990). Located 14 km north of Lockhart.

1:250 000 topographic map: Jerilderie
LGA: Lockhart

546 BURROWS, G. & LEVETT, G. (1991)

Plant species list for Bethungra Reserve (a N.S.W. State Recreation Area)
Charles Sturt University – Riverina (unpub.)

List of about 80 native species (excluding grasses) for area 4 km east of Bethungra
 1:250 000 topographic map: Cootamundra
 LGA: Juneec

547 NORRIS, E.H. & THOMAS, J. (1991)

Vegetation on rocky outcrops and ranges in central and south-western New South Wales

Cunninghamia 2(3): 411–441

Lists 340 species (55 exotic) from 19 sites on sandstone, granite, slate or rhyolite geology. Discussion of significant species, vegetation and conservation and management issues. Covers an area from Roto to Corowa including parts of the Central Western Slopes, South Western Slopes and South Western Plains subdivisions.

1:250 000 topographic maps: Ivanhoe, Manara, Narrandera, Cargelligo, Jerilderie, Booligal

LGA: Central Darling, Carrathool, Murrumbidgee, Griffith, Leeton, Urana, Corowa, Narrandera, Lockhart

548 WHITING, E. (1988)

Plant list for Bunganbil State Forest

Part of a report submitted to NSW National Parks & Wildlife Service (unpub.) 113 species arranged alphabetically by family. Common names and introduced species included. Located 39 km north of Narrandera.

1:250 000 topographic map: Narrandera

LGA: Narrandera

549 WHITING, E. (1988)

Plant list for Lake Talbot Reserve, Narrandera

Forms part of report to NSW National Parks & Wildlife Service (unpub.)

Eighty-one species arranged alphabetically by family. Common names and introduced species included.

1:250 000 topographic map: Narrandera

LGA: Narrandera

550 WHITING, E. (1988)

Plant list for Moombooldool – Kamarah roadside

Part of a report submitted to NSW National Parks and Wildlife Service (unpub.)

Ninety species listed alphabetically by family. Common names and introduced species included. Kamarah is 13 km west of Ardlethan on the Griffith Road.

1:250 000 topographic map: Narrandera

LGA: Narrandera

551 WHITING, E. (1988)

Plant list for the reserve north of Kamarah

Part of a report submitted to the NSW National Parks and Wildlife Service (unpub.)

150 species listed alphabetically by family. Common names and introduced species included. Kamarah is 13 km west of Ardlethan on the Griffith Road.

1:250 000 topographic map: Narrandera

LGA: Narrandera

552 WHITING, E. (1988)

Species additional to the published list for The Rock Nature Reserve (unpub.)

17 species listed additional to list held by the National Parks & Wildlife Service, Griffith.

1:250 000 topographic map: Wagga Wagga

LGA: Lockhart

553 WHITING, E. (1991–1992)

Species Lists for the Northern Riverina (unpub.)

Species lists of areas within a 150km radius of Leeton in the Northern Riverina (includes some of above references). State Forests included: MIA Forests 2 & 3, Binya State Forest, Boona State Forest, Kulki State Forest, Kockibitoo State Forest, Livingstone State Forest, Jurambula State Forest, Kolkilbertoo State Forest, Mejum State Forest, Ardlethan State Forest, Beckom State Forest, Bunganbil State Forest, Billenbah State Forest, Gillenbah State Forest, Buckingbong State Forest, Berry Jerry State Forest. Other areas include roadsides and Mt. Galore, Lake Cargelligo Weir and floodplain and Yanco Weir.

Pertinent also to the South Western Plains and the Central Western Slopes.

1:250 000 topographic map: Narrandera

LGA: Leeton, Narrandera

See also Margules & partners, P & J Smith ecological consultants, Department of Conservation Forests and Lands Victoria (1990)

NORTH WESTERN PLAINS

554 WADE, T. (1992)

The Brigalow outlier: a resource inventory of the brigalow vegetation communities west of the Culgoa River

Department of Conservation and Land Management

A detailed study of an area north of Bourke, including vegetation descriptions and floristic lists, and suggesting that this vegetation is floristically distinct from

brigalow communities elsewhere.
 1:250 000 topographic map: Enngonia
 LGA: Bourke, Brewarrina

See also NFWP – Pressey, Conn & Porter (1990)

SOUTH WESTERN PLAINS

- 555 BRICKHILL, J. (1985-1988)
 Plant list, Willandra National Park
 (unpub.)
 List of 100 native and introduced species with common names and comments on distribution.
 1:250 000 topographic map: Booligal
 LGA: Carrathool
- 556 McINTYRE, S., LADIGES, P.Y. & ADAMS, G. (1988)
 Plant species-richness and invasion by exotics in relation to disturbance of wetland communities on the Riverine Plain, N.S.W.
Australian Journal of Ecology 13(4): 361–373
 Three habitats are examined in the irrigation districts which were subjected to varying intensities of human-induced disturbance. They were: swamps, road side table-drains, and rice crops. An appendix contains a species list of 125 macrophytic plants including seed bank records. Exotics included.
 1:250 000 topographic maps: Narrandera, Deniliquin, Jerilderie
 LGA: Carrathool, Murrumbidgee, Jerilderie, Wakool, Murray, Conargo
- 557 PICKARD, J. (1974)
 Floristic lists from around gypsum mines near Ivanhoe
 Royal Botanic Gardens, Sydney (unpub.)
 A checklist of 66 species found around 5 gypsum mines (Marlow, A.P.I., Manara, Beilpajah, and un-named) in the Ivanhoe area.
 1:250 000 topographic map: Ivanhoe
 LGA: Central Darling
- 558 PORTENERS, M.F. (1993)
 The natural vegetation of the Hay, Deniliquin and Booligal 1:250 000 maps sheets
Cunninghamia 3(1): 1–122
 Species list of 800 native and naturalised plants. Sixteen vegetation communities. Vegetation maps at 1:250 000 scale.
 1:250 000 topographic maps: Hay, Deniliquin, Booligal
 LGA: Carrathool, Hay, Balranald, Murrumbidgee, Windouran, Conargo, Wakool, Murray, Central Darling

- 559 PRESSEY, R.L., BELL, F.C., BARKER, J., RUNDLE, A.S., BELCHER, C.A. (1984)
 Bio-physical features of the Lachlan–Murrumbidgee confluence, South-Western New South Wales
 NSW National Parks and Wildlife Service (unpub.)
 Discusses the hydrology, geomorphology, soils, vegetation, fauna, alteration to the environment, and management of the area with recommendations. Appended species list contains 300 plant species found in this survey or from other sources. Also includes an appended list of new plant records for the botanical region and their recording sites. Maps included.
 1:250 000 topographic maps: Balranald, Hay
 LGA: Balranald, Hay, Wakool
- 560 SEMPLE, W.S. (1986)
 The Finley Arboretum site: A brief description, including a list of vascular plants
Western Region Technical Bulletin No.26 (Soil Conservation Service of NSW)
 Notes on soils and vegetation. Ninety-six species recorded from the site (about 5 km south of Finley), 1984–1986, arranged alphabetically by family with common names. Photographs of the arboretum included.
 1:250 000 topographic map: Jerilderie
 LGA: Berrigan
- See also NFWP – Pressey, Conn & Porter (1990); SWS – Norris & Thomas (1991); SFWP – Scott (1992); NSW general – Margules & partners, P & J Smith ecological consultants, Department of Conservation Forests and Lands Victoria (1990)

NORTH FAR WESTERN PLAINS

- 561 DUNCAN, A. AND COVENY, R.G. (1988)
 Sturt National Park floristic list
 (unpub.)
 This listing of 420 species was compiled from species lists prepared by Bob Coveny, the Anzsas Botany Group: Barbara Wiecek, Elizabeth Brown, Tony Rodd and Jan Reilly.
 1: 250 000 topographic map: Milparinka
 LGA: unincorporated area
- 562 PRESSEY, R.L., CONN, J.S. & PORTER, J.L. (1990)
 Vascular plants with restricted distributions in the Western Division of NSW
Proceedings of the Linnean Society of N.S.W. 112: 213–227
 A systematic listing of 209 plant species. Categories and Priorities as defined in text are given as are rare or threatened and presumed extinct plants.
 1:250 000 topographic maps: Ana Branch, Ponnecarie, Balranald, Booligal, Menindee, Manara, Ivanhoe, Nymagee, Broken Hill, Wilcannia, Barnato, Cobar, Cobham Lake, White Cliffs, Louth, Bourke, Walgett, Milparinka, Urisino, Yantabulla, Enngonia, Angledool

LGA: Wentworth, Balranald, Central Darling, Carrathool, Cobar, Bourke, Walgett, Brewarina

SOUTH FAR WESTERN PLAINS

563 FOX, M.D. (1991)

The natural vegetation of the Ana Branch – Mildura 1:250 000 map sheet (New South Wales)

Cunninghamia 2(3): 443–493

This paper includes a detailed vegetation map together with a list of 300 species with 33 exotic species in 15 vegetation communities. There are several significant plant communities in the area with seven rare or endangered species. Only 1% of the region is in a formal conservation reserve.

1:250 000 topographic maps: Ana Branch, Mildura

LGA: Wentworth, Unincorporated area

564 NOBLE, J.C. (1989)

Fire studies in mallee (*Eucalyptus* spp.) communities of western New South Wales: the effects of fires applied in different seasons on herbage productivity and their implications for management.

Australian Journal of Ecology 14(2): 169–187

The post-fire development of herbaceous understories of *Triodia*/mallee burnt in different seasons was studied over a 3 year period. An appended species list contains 67 species and their presence or absence in 1978–81 and 1984.

1:250 000 topographic map: Ponnecarie

LGA: Wentworth

565 SCOTT, J.A. (1992)

The natural vegetation of the Balranald–Swan Hill area

Cunninghamia 2(4): 597–652

This paper includes a detailed vegetation map together with a list of about 500 species including exotic species. Twenty vegetation communities are described and vegetation distribution, species composition, landuse and changes to native vegetation, and conservation of vegetation are discussed.

1:250 000 topographic map: Balranald, Swan Hill

LGA: Wentworth, Balranald, Wakool, Hay

See also NFWP – Pressey, Conn & Porter (1990)

NEW SOUTH WALES GENERAL

566 ADAM, P., WILSON, N.C., & HUNTLEY, B. (1988)

The phytosociology of coastal saltmarsh vegetation in New South Wales.

Wetlands (Australia) 7(2): 35–85

Lists 217 taxa in twenty-five saltmarsh communities. Most communities are species poor, with a small number of dominant species.

1:250 000 topographic map: Bega, Mallacoota, Ulladulla, Wollongong, Sydney, Newcastle

LGA: Great Lakes, Port Stephens, Newcastle, Lake Macquarie, Wyong, Gosford, Wollongong, Wingecarribee, Eurobodalla, Bega Valley, Sutherland, Randwick, Waverley, Woollahra, Manly, Warringah

- 567 ADAM, P., STRICKER, P., WIECEK, B.M. & ANDERSON, D.J. (1989)

The vegetation of seacliffs and headlands in New South Wales, Australia

Australian Journal of Ecology 14(4): 515-547

A phytosociological survey of seacliff and headland vegetation from Forster to the Victorian border. Analysis of the data led to the recognition of 15 plant communities. Includes 328 species native and introduced.

1:250 000 topographic map: Bega, Mallacoota, Ulladulla, Wollongong, Sydney, Newcastle

LGA: Great Lakes, Port Stephens, Newcastle, Lake Macquarie, Wyong, Gosford, Wollongong, Wingecarribee, Eurobodalla, Bega Valley, Sutherland, Randwick, Waverley, Woollahra, Manly, Warringah

- 568 CAROLIN, R. & CLARKE, P. (1991)

Beach plants of south-eastern Australia

Sainty & Associates: Sydney

Descriptions and photographs of about 180 coastal plants with notes on habitat and ecology. Based on Clarke, P.J. (1989a,b).

1:250 000 topographic maps: Bega, Ulladulla, Wollongong, Sydney, Newcastle, Hastings, Coffs Harbour, Maclean, Tweed Heads

LGA: Bega Valley, Eurobodalla, Wingecarribee, Wyong, Port Stephens, Great Lakes, Kempsey, Nambucca, Bellingen, Ulmarra, Maclean, Richmond River, Ballina, Byron, Tweed, Sutherland, Randwick, Waverley, Woollahra, Manly, Warringah

- 569 CLARKE, P.J. (1989a)

Coastal dune vegetation of New South Wales

Technical Report No.89/1 University of Sydney, Coastal Studies Unit, and Technical Report No.21, Soil Conservation Service of NSW.

The structure and floristic composition of the Holocene sand dunes of NSW are described. Species are described from 247 sites. Contains an annotated bibliography on the vegetation of coastal sand dunes of NSW: 45 reviewed references with headings of: study location, physical environment, methods, general vegetation, sand dune vegetation, species list, management and references.

1:250 000 topographic maps: Bega, Ulladulla, Wollongong, Sydney, Newcastle, Hastings, Coffs Harbour, Maclean, Tweed Heads

LGA: Bega Valley, Eurobodalla, Wingecarribee, Wyong, Port Stephens, Great Lakes, Kempsey, Nambucca, Bellingen, Ulmarra, Maclean, Richmond River, Ballina, Byron, Tweed, Sutherland, Randwick, Waverley, Woollahra, Manly, Warringah

570 CLARKE, P.J. (1989b)

Coastal dune plants of New South Wales

Technical Report No.89/4 University of Sydney, Coastal Studies Unit, and Technical Report No.22, Soil Conservation Service of NSW.

Part of a study on coastal sand dune management. Includes 386 species with individual plant identification, morphology, life history, physiology, climate, soil, regeneration, useful properties, distribution, and habitat. The species list includes common name, life form, habitat and distribution and introduced species are included.

1:250 000 topographic maps: Bega, Ulladulla, Wollongong, Sydney, Newcastle, Hastings, Coffs Harbour, Maclean, Tweed Heads

LGA: Bega Valley, Eurobodalla, Wingecarribee, Wyong, Port Stephens, Great Lakes, Kempsey, Nambucca, Belligen, Ulmarra, Maclean, Richmond River, Ballina, Byron, Tweed, Sutherland, Randwick, Waverley, Woollahra, Manly, Warringah.

571 CLARKE, P.J. & CHAPMAN, D.M. (1989)

Coastal Dune Database

Technical Report No.89/2 University of Sydney, Coastal Studies Unit

The database DUNESVY is used to document the coastal sand dune environments of NSW, their site characteristics and plant species. Part of joint research project on the coastal dunes of NSW and their management undertaken by the University of Sydney Coastal Studies Unit and the Soil Conservation Service of NSW.

See Clarke, P.J. (1989a,b) above

572 MARGULES & PARTNERS, P & J SMITH ECOLOGICAL CONSULTANTS, DEPARTMENT OF CONSERVATION FORESTS AND LANDS VICTORIA (1990)

River Murray riparian vegetation study

Murray-Darling Basin Commission

The study area includes the floodplain of the Murray River and its anabranches, and includes the Edward-Wakool system, from below Hume Dam to the upper end of Lake Alexandrina.

Data collected were the species present, their relative abundance, the condition of the eucalypts, the amount of eucalypt regeneration and indices of grazing pressure. Thirty-seven plant communities were identified. Structural vegetation map included. Species list includes 660 species by community and river section. Sixty-eight threatened species listed.

1:250 000 topographic map: Mildura, Balranald, Swan Hill, Deniliquin, Jerilderie, Bendigo, Wangaratta

LGA: Wentworth, Balranald, Wakool, Murray, Berrigan, Corowa, Hume, Holbrook, Tumbarumba

Final manuscript received 23 April 1993

Manuscript accepted 4 May 1993

Bryophytes of the Royal Botanic Gardens, Government House and the Domain, Sydney

H.P. Ramsay, R.G. Coveny, E.A. Brown and A.K. Brooks

Abstract

H.P. Ramsay, R.G. Coveny, E.A. Brown & A.K. Brooks. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney NSW, Australia 2000), 1993. Bryophytes of the Royal Botanic Gardens, Government House and the Domain, Sydney. *Cunninghamia* 3(1): 215–229. More than 90 species of bryophytes (70 mosses, 24 hepatics and one anthocerot) have been collected in the Royal Botanic Gardens, Government House and the surrounding Domain, an area of 30 hectares, Sydney. Species present include some new records for New South Wales and one for Australia and include representatives of up to 25 families of mosses and 13 families of hepatics.

Introduction

The Royal Botanic Gardens, Sydney lies on the foreshores of Port Jackson (Sydney Harbour) at Farm Cove (Fig. 1). Although bryophytes have been studied at the National Herbarium of New South Wales, in the Royal Botanic Gardens, Sydney since the late nineteenth century, few specimens are annotated as having been collected there and no species list has been published for the Royal Botanic Gardens, Government House or the Domain. The site occupied by the Royal Botanic Gardens has been cultivated for agriculture and horticulture since the earliest days of European settlement which began in Australia on this site, in January 1788 (Gilbert 1986).

Watercolours of adjacent Sydney Cove by William Bradley in 1788 (Bradley 1786–1792) show relatively dense stands of trees above a rocky foreshore, but with grassy understorey, behind the shoreline. The original vegetation behind the mudflats consisted of eucalypt woodland, 'brushwood' and a variety of smaller plants, occurring on exposed rocky outcrops and in the more sheltered fern gullies of the creek beds, while near the salt water the vegetation included Swamp Oak, *Casuarina glauca*, Port Jackson Fig, *Ficus rubiginosa*, and teatrees. Several species of eucalypt as well as Turpentine, *Syncarpia glomulifera* and Smooth-Barked Angophora, *Angophora costata* were present (Wilson 1986).

The underlying bedrock is sandstone and soils are sandy and shallow with some rocky outcrops. Reclamation of low lying land on the foreshores of the Harbour and building of the sea wall enabled the area of land available for cultivation and recreation to be increased from the original small farm area. Soils have since been modified by supplementation with other soils, fertilisers and mulching.

At present the Royal Botanic Gardens and Domain occupy an area of 30 hectares with the Domain parkland acting as an insulator from the Central Business District and its high-rise buildings (Johnson in Wilson 1986). By 1986 all that remained of the original vegetation were some gnarled trees of *Angophora costata*, *Ficus rubiginosa*, *Casuarina glauca* and a few specimens of *Eucalyptus pilularis*, *E. tereticornis*, *E. resinifera*, *Glochidion ferdinandi* and *Rapanaea variabilis* that are clearly descended from ones that were on the site (Wilson 1986, L.A.S. Johnson pers. comm.).

History of bryophyte collections and bryology at the National Herbarium of New South Wales (NSW)

Attached to and forming an integral part of the Royal Botanic Gardens complex are the administrative, research and educational services. The Brown Building houses the National Herbarium of New South Wales, referred to by its acronym NSW. Among the large array of plant specimens held is an extensive collection of Australian bryophytes, one of the largest in Australia (Ramsay & Seur 1990).

The earliest bryophyte specimens collected in New South Wales and held in the National Herbarium date back to the 1880's. Three prominent figures, Thomas Whitelegge, William Forsyth and William Walter Watts, whose specimens form the basis of the Australian collections at NSW, contributed significantly to knowledge of bryophytes in Australia, particularly New South Wales.

Thomas Whitelegge (1850–1927)

Thomas Whitelegge (1850–1927), born in Stockport, Cheshire, England, arrived in Sydney in early 1883 and was appointed to the Australian Museum, being in charge of Invertebrates from 1883–1908 (Obituary 1927). He also had an interest in ferns and mosses and in 1884 began to gather information on the mosses of New South Wales primarily in Sydney, Gosford, Moss Vale and Blue Mountains. At the urgent request of Dr. V.F. Brotherus in Helsinki, who was preparing the volumes on mosses for Engler & Prantl's *Die Natürlichen Pflanzenfamilien*, Whitelegge secured nearly 100 species in 1890–91. In 1892 he compiled a list, revised by Brotherus, of some 300 New South Wales species (Watts & Whitelegge 1902) but this was not published. In 1898 Whitelegge met W.W. Watts and they jointly presented a list of some 500 species for publication by the Linnean Society of New South Wales. Later the manuscript was withdrawn in favour of a broader list (Census) covering Australia. This was published in their joint names in 1902 and 1905, and dealt with the acrocarpous mosses [the pleurocarpous species were published later after their deaths (Burgess 1932, 1935)]. Whitelegge's position at the Australian Museum in the early 1900s prevented him from continuing research on mosses and he handed over this activity to Watts.

William Forsyth (1864–1910)

In the 1890s Joseph Henry Maiden, Director of the Sydney Botanic Gardens, encouraged bryophyte collecting and made sure they were included in the collections of the National Herbarium of New South Wales. He delegated William Forsyth to concentrate on bryophytes during general field excursions.

William Forsyth, born near Crieff, Perthshire, Scotland, came from a farming background. In 1886 he became overseer for Centennial Park, Sydney and from 1898 he added to this responsibility for collecting and maintaining bryophytes in the National Herbarium of New South Wales at the urging of Maiden. His enthusiasm for the task resulted in the addition of some 1200 specimens in just two years. He was Curator of Bryophytes from 1898 to 1903 adding many new Australian species during field trips on his own or with Maiden, W.F. Blakely and others to many areas of New South Wales.

His publication *Contribution to a knowledge of the moss flora of N.S.W.* (Forsyth 1899), recorded 61 species of which 43 were new to the colony and 26 were from Port Jackson. In 1900 he added collections from Richmond and Tweed Rivers, New England, Germanton (now Holbrook) and Tumbarumba. He also began an exchange program with overseas bryologists on whom he depended for identifications, in particular Brotherus in Helsinki.

W.W. Watts (1856–1920)

The Rev. William Walter Watts was born in Devon, England. Because of ill health he was sent by his church to Australia in 1887 (Brisbane and later northern New South Wales) to recuperate. He moved to Sydney in 1895. His major collections were made whilst he was minister of the Presbyterian Church in Ballina, far North Coast of New South Wales, and many collections were made at outlying timber camps at a time when the Big Scrub was being cut to open up the land for farming (Ramsay 1980).

In 1909 it was arranged that — “Rev. W.W. Watts and myself [Mr. A.E. Goddard the then curator] shall enter into a complete and detailed examination of the mosses during 1909 from the standpoint of external morphology and histology so that the greatest possible use and value may accrue from the collection in the herbarium.” (Sydney Botanic Gardens Annual Report 1909). However, Goddard left for South Africa in 1909 and Watts became Honorary Curator of Cryptogams (1909–1916) until he moved to Victoria. In 1911 the Whitelegge collections, including mosses and lichens, purchased from Goddard, were added to the Herbarium. The collections of W. Forsyth and W.W. Watts (more than 12,000 specimens) were incorporated after their deaths.

Apart from his contributions to bryology in terms of specimens collected, it was Watts’ publications with Brotherus and Stephani (17 in all) (Ramsay 1980), that brought the attention of the world to Australian, particularly New South Wales and Queensland taxa (e.g. Brotherus & Watts 1912, 1915, Stephani & Watts 1914 etc). Some 167 new moss species and more than 70 hepatics were named based on Watts’ collections.

Study site and collections

Specimens of bryophytes (mosses, hepatics and anthocerotes) were collected in areas of the Royal Botanic Gardens, Government House and Domain over a period of over two years from 1989 to early 1991. This proved to be a particularly good period for bryophyte growth and development as Sydney had above-average rains during much of the time of the study. The majority of collections were made by R.G. Coveny, E.A. Brown and A. Brooks, with some assistance from R. Makinson & J. Wood. Identifications are based on published information in floras, checklists and monographs (Catchside 1980; Catchside & Frahm 1985; Crum 1991; Frahm 1985, 1987; Scott 1985; Scott & Bradshaw 1986; Scott & Stone 1976; Touw & Falter-van den Haak 1989. All specimens have been lodged at NSW as vouchers for future studies. An appendix, providing a complete list of identification numbers for the vouchers, will be deposited in the library at NSW.

The areas investigated were the Royal Botanic Gardens (RBG), Government House gardens and the Domain (Fig. 1). The names for sections of the Botanic Gardens (Palace, Upper, Middle and Lower) are indicated on Fig. 1 by number and used here for convenience to describe the features of the areas.

1. The Palace Garden — bounded by Macquarie Street and the Cahill Expressway and south of the Conservatorium of Music — includes various garden beds, the Rose Garden, stone walls, lawns and paths. A sunken garden, the Memorial Garden to Pioneers (Men and Women), is located in this area.

2. The Upper Garden — trees, lawns, garden beds, stone paths and walls lie adjacent to this but are separated from the Palace Garden by the Nursery behind the Pyramid and the Arc glasshouses of the Tropical Centre. The eastern border is on Mrs Macquaries Road where the Anderson, Brown and Cunningham buildings are located.

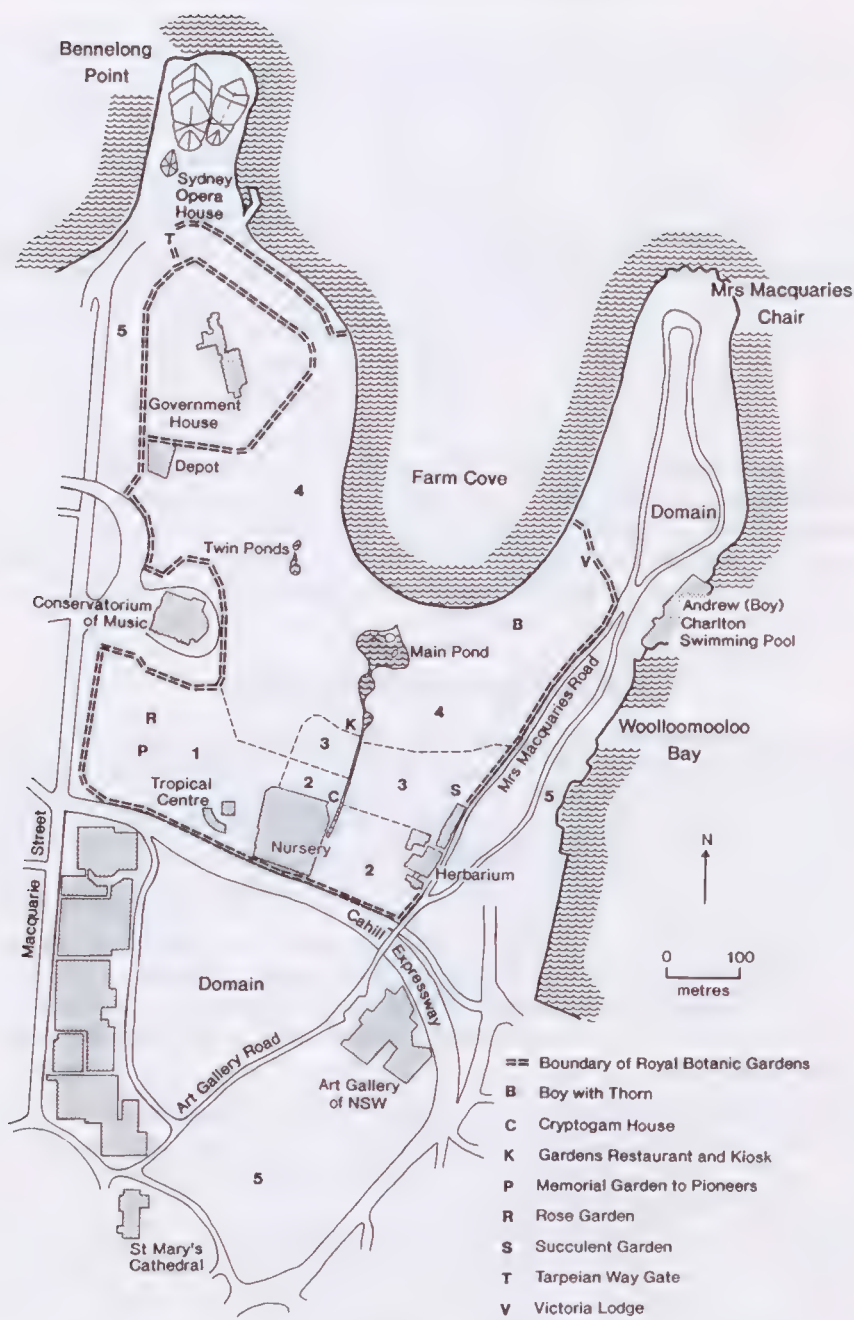


Figure 1. Map of the Royal Botanic Gardens Sydney, the Domain and adjacent areas showing the main collection sites referred to. 1. The Palace Garden. 2. The Upper Garden. 3. The Middle Garden. 4. The Lower Garden. 5. The Domain. Modified from 1990 general map published by the Royal Botanic Gardens, Sydney.

3. The Middle Garden — includes a succulent garden on Mrs Macquaries Road, a large brick-walled creek (known as Botanic Gardens Creek), part of a palm grove to the west, scattered large trees and formal gardens.

4. The Lower Garden — adjacent to Farm Cove and extending from Mrs Macquarie's Road to the Opera House; in the centre Botanic Gardens Creek feeds into the Main Pond, the Gardens Restaurant being above the ponds. Large trees, garden beds, paths and sandstone outcrops occur in this area. The Boy with Thorn statue and Tarpeian Way Gate are also in this area.

5. The Domain — extends both south of the Cahill Expressway, opposite and beside the Art Gallery, then north of the Expressway along Mrs Macquaries Road and Woolloomooloo Bay and past the Andrew Charlton Pool to Mrs Macquaries Chair. Also included is a narrow strip between the Gardens and Macquarie Street towards the Opera House.

The habitats of particular significance for bryophytes in the Royal Botanic Gardens include the brick and stone-walled Botanic Gardens Creek, Twin Ponds and island near the Gardens Restaurant, grounds outside the Tropical Centre glasshouses, potting shed and nursery glasshouses, paths and lawns, sandstone walls and stairs, large sandstone outcrops and old cut rock-faces in the Domain, near Mrs Macquaries Chair and near the Opera House, and the bark of trees.

Bryophytes present in the Royal Botanic Gardens, Government House and the Domain, Sydney.

We present here annotated species lists for 1.) Mosses and 2.) Hepatics and Anthocerotales, with expanded notes on mosses not described in detail in Scott & Stone (1976) or Catcheside (1980), and hepatics not mentioned in Scott (1985). Distribution notes for mosses refer to Ramsay (1984) where previous records are given for the Central Coast of New South Wales (CC), in which the Royal Botanic Gardens lie. As there are no details for the distribution of hepatics within New South Wales we referred to Scott (1985) for records of species present in New South Wales.

Species previously collected in the Gardens include *Fabronia australis* as *F. tayloriana* by W.W. Watts in 1910 and 1914; *F. scottiae* by W. Forsyth in 1899, W.W. Watts in 1899 and 1910; Lovegrove in 1901 and E. Cheel in 1901; *F. brachyphylla* by W. Forsyth in 1900; *Vesicularia* sp. on pots in fernhouse. The only previous hepatic specimen in NSW from the Royal Botanic Gardens is *Lunularia cruciata* (L.) Dumort. collected by A.N. Rodd in 1964 near the glasshouses.

1. Annotated species list of mosses of the Royal Botanic Gardens (RBG), Government House and the Domain.

+ not previously reported for Central Coast (CC) in New South Wales (Ramsay 1984). If a species has been collected only once or twice previously Ramsay has noted this.

++ new record for N.S.W.

Sphagnaceae

Sphagnum cristatum Hampe. Present in pots with insectivorous plants in the potting shed — probably brought in for soil improvement. Naturally occurring in soak areas.

Archidiaceae

Archidium watsii (Broth.) Stone [syn. *Splachnobryum watsii* Broth. fide Stone 1984: 153-157.]. Domain near Mrs Macquaries Point, on sandstone rock near retaining wall.

This species was originally known only from two specimens, collected at Watsons Bay and Parsley Bay 1899 (Watts 2450, 2479) Sydney but has now been reported from Queensland by Stone (1984). It is the first species of *Archidium* confirmed for N.S.W.

Dawsoniaceae

Dawsonia polytrichoides R. Br. Brought in with plant material in nursery pot although this species does occur in wet forested valleys in the region.

Fissidentaceae

Fissidens dietrichiae C. Muell. On wall of Botanic Gardens Creek. This name is listed in error as a synonym for *F. crassipes* Wils. ex B.S.G. for New South Wales in Ramsay (1984). *F. crassipes* has not been found in Australia (Stone pers. comm.). Previously recorded from fewer than three collections for CC.

Fissidens leptocladus C. Muell ex Rodw. On moist brickwork of Botanic Gardens Creek, on brickwork and soil on hillside near the Opera House, near the Government House Depot, and in Domain overlooking Woolloomooloo Bay. Known from fewer than three collections in CC.

Fissidens linearis Brid. var. *linearis* [fide Stone 1991: 403-405; syn. *F. humilis* Dix. & Watts and syn. *F. aeruginosus* Hook. f. & Wils. var. *arcuatulus* Stone fide Stone 1990: 245-260]. Botanic Gardens Creek, Domain near Andrew Charlton Pool, on earth bank among rocks on Mrs Macquaries Point. Common species of wet earth banks.

Fissidens oblongifolius Hook. f. & Wils. On sandstone rocks between the Brown and Cunningham Buildings.

Fissidens perangustus Broth. On soil in Pioneer Memorial Garden in RBG and Domain overlooking Woolloomooloo Bay. Listed by Watts & Whitelegge (1902) for New South Wales but not confirmed in Ramsay (1984, p. 513)

Fissidens pungens C. Muell. & Hampe. Common in various areas, floor of large drain, on small island near Kiosk, soil near Pyramid glasshouses, steps near Government House, between the large pond and Gardens Restaurant. Common on soil.

Fissidens semilimbatus C. Muell. & Hampe [listed as a synonym of *F. taylorii* C. Muell. in Ramsay (1984) and Scott & Stone (1976) but now considered a separate species (Stone pers. comm.)]. On spillway of Botanic Gardens Creek, on brickwork near the Cryptogam House, Domain on moist sandstone rock. Common in CC area.

Fissidens rigidulus Hook. f. & Wils. subsp. *rigidulus*. An aquatic species found here only on brickwork of Botanic Gardens Creek below water level. Confined to running water, known from fewer than three collections from CC.

Ditrichaceae

Ceratodon purpureus (Hedw.) Brid. subsp. *convolutus* (Reichdt) J.S. Burley [fide Burley & Pritchard 1990: 17-76]. Collected on brickwork in Domain, near Conservatorium and Government House on soil and in soil in cracks near Botanic Gardens Creek. A cosmopolitan species, commonly occurring as coloniser of disturbed soil.

Ditrichum difficile (Dub.) Fleisch. In soil on sandstone cliff overlooking the Opera House. Frequently found on earth banks.

Dicranaceae

Campylopus bicolor (F. Muell.) Wils. var. *bicolor*. On soil outside Herbarium buildings and on rock in Domain near Mrs Macquaries Chair.

Campylopus clavatus Hook. f. & Wils. On pots in nursery. Generally common on rocks.

Campylopus incrassatus C. Muell. On soil cracks on wooden bridge over Botanic Gardens Creek. Recorded as *C. flavo-viridis* Dus. [fide Catcheside & Frahm 1985: 363] = *C. incrassatus* [fide Frahm 1987: 715].

Campylopus introflexus (Hedw.) Brid. Young plants in crevices of bark on *Brachychiton rupestre* with *Tortula pagorum* and lichen, sandstone rocks and near Andrew Charlton Pool in Domain. Lacking the usual hyaline apex but clearly *C. introflexus* from leaf sections. Common coloniser of rocks.

Campylopus pyriformis (Schultz) Brid. Domain near Andrew Charlton Pool, Mrs Macquaries Chair and on old cut sandstone cliff opposite the Opera House. Recorded as *C. pallidus* Hook. f. & Wils. from CC [synonyms *C. novae-valesiae* Broth., *C. woollsii* (C. Muell.) Par. fide Frahm 1987: 720; *C. pallidus* fide Corley & Frahm 1982 : 187–190].

Dicnemoloma pallidum (Hook.) Wijk & Marg. On rock near the Brown Building. Common coloniser of sandstone rocks.

Trematodon suberectus Mitt. On soil on brick in nursery.

Leucobryaceae

++*Leucobryum aduncum* Dozy & Molk. On soil at base of *Ficus rubiginosa*. This species was identified by D.G. Catcheside. Although not previously reported from N.S.W. many specimens have probably been misidentified as *L. candidum*.

Pottiaceae

Barbula calycina Schwaegr. In lawn with other mosses below and east of Succulent Garden and wall, RBG. A common moss of disturbed soil.

Barbula unguiculata Hedw. On Boy with Thorn Statue, on moist soil in lawns in RBG. Common coloniser of soil.

Gymnostomum calcareum Nees & Hornsch. [= *G. aeruginosum* Sm. fide Zander 1977: 233–269, see note in Catcheside 1980: 187]. On moist old cut sandstone cliff overlooking the Opera House and on calcareous soil in the Domain. A calcareous moss suggesting that the sandstone rock surface possibly had a surface wash of cement dust or other calcareous material.

Pottia truncata (Hedw.) B.S.G. on soil in lawn – Domain, Government House and near the Tarpeian Way Gate. Common coloniser of soil.

Tortula muralis Hedw. On sandstone blocks near Government House, common on cement in brick walls, footpaths, stonework of Botanic Gardens Creek, near Andrew Charlton Pool in Domain and at Mrs Macquaries Point. Common on calcareous brickwork, and rocks.

Tortula pagorum (Milde) De Not. Common on bark of trees such as *Lophostemon confertus*, *Fraxinus chinensis*, *F. Xcanadensis*, *Populus* sp., *Ficus hillii*, *F. bengalensis*, *F. macrophylla*, *Schinus areira*, *Magnolia grandiflora*, on brickwork of Succulent Garden and cement steps of Rose Garden. Frequent epiphyte on rough-barked trees.

Tortula papillosa Wils. Uncommon in RBG, epiphytic on *Bauhinia patersoniana* in Gardens [tree since removed] and on tree in Government House Grounds. Known from fewer than three collections in CC.

Weissia controversa Hedw. var. *controversa* Hedw. Common on soil on brickwork in the Gardens, and near the Tarpeian Way Gate and Cryptogam House. Very common on soil.

+*Weissia controversa* Hedw. var. *gymnostoma* (Dix.) Sainsb. [Capsule was clearly gymnostomous] near Boy with Thorn Statue.

Ptychomitriaceae

Ptychomitrium australe (Hampe) Jaeg. Sandstone rock near Herbarium buildings and Government House. Recorded from fewer than three collections in CC.

Funariaceae

Funaria hygrometrica Hedw. On soil in Domain, on pots in glasshouse, old rose garden and in nursery garden bed near the Gardens Restaurant. Very common weed in pots in nurseries and as a coloniser of soil after fires.

Bryaceae

Bryum argenteum Hedw. Common on soil in footpaths and brick walls throughout the Gardens and Domain, cement in walls of Government House and in cracks of wall of Botanic Gardens Creek. Common on calcareous substrata particularly paths and walls.

Bryum billardierei Schwaegr. var. *billardierei*. On walls of Botanic Gardens Creek, soil and in crevices in rock wall near Andrew Charlton Pool. A common moss of damp soil.

Bryum capillare Hedw. Garden bed, on pots in nursery, wall of Botanic Gardens Creek, on soil and sandstone rock overhang in Domain.

Bryum ?chryseuron C. Muell. Near swimming pool in Domain.

Bryum dichotomum Hedw. Common on soil and brickwork in RBG, pots in nursery, glasshouses, footpaths, sandstone rock near Brown Building, brickwork in Succulent Garden and sandstone rock near Conservatorium, on tree bases and sandstone blocks near Government House, on brickwork and sandstone rocks in the Domain and at Mrs Macquaries Chair. Common colonist of soil.

Bryum pachytheca C. Muell. Brickwork and wall in Pioneer Memorial Garden.

++*Bryum rubens* Mitt. Soil outside Pioneer Memorial Garden. No previous report of this moss for N.S.W. [some earlier collections included in the *B. erythrocarpum* complex may be this species. Refer to Catcheside 1980: 277]

Bryum ?sauteri B.S.G. On sandstone rock outside Brown Building. Another member of the *B. erythrocarpum* complex. Collected fewer than three times in CC.

+*Bryum subapiculatum* Hampe. Southern side of Botanic Gardens Creek, on soil in Domain near Mrs Macquaries Point.

Bryum subfasciculatum (Hampe) Mitt. Common in wet soaks in grass in RBG, on soil at base of trunk of *Brachychiton rupestre*, grass near Government House and with wet grass in Domain. Frequent on soil.

Bryum torquescens Bruch ex De Not. On pots in nursery. (Previously published as *B. capillare* ssp. *torquescens* (De Not.) Kindb.)

Leptobryum pyriforme Hedw. Soil in pots in nursery, and in Depot near glasshouses, on sandstone overhang in Domain [plants of this species covered in rhizoidal gemmae were collected in Hyde Park in Central Sydney]. Common weed of pots in nurseries.

Orthodontium lineare Schwaegr. subsp. *sulcatum* (Hook. f. & Wils.) Meijer. On moist soil at Government House and twin ponds. More commonly found on burnt logs in forests.

Pohlia tenuifolia (Jaeg.) Broth. On soil with other mosses including *Barbula calycina* in RBG. Known from fewer than three collections in CC.

Aulacomniaceae

Aulacomnium palustre (Hedw.) Schwaegr. Found with *Dawsonia polytrichoides* and with *Bryum billardierei* on pots in potting shed. The presence of pseudopodia bearing leaf-like gemmae is characteristic. As all previous New South Wales reports are from the North Coast and Southern Tablelands, this is most likely an introduction from elsewhere.

Bartramiaceae

+*Philonotis ?austrofalcata* Broth. & Watts. The only previous locality in New South Wales is Yarrangobilly in the Southern Tablelands (ST). This may be an introduction to CC.

Philonotis dicranellacea (C. Muell.) Watts & Whitel. On moist sandstone rocks near Govt. House, on sandstone rocks on earth embankment in Domain and near Andrew Charlton Pool.

Philonotis tenuis (Tayl.) Reichdt. On pots in nursery, glasshouses with *Funaria hygrometrica*, brick wall in Royal Botanic Gardens, on damp soil below hanging rock and on sandstone rocks near Andrew Charlton Pool in Domain. Common in seepage areas or under rocks.

Fabroniaceae

Fabronia australis Hook. Epiphytic on trees, e.g. trunk of Rosaceous tree, southern side of trunk of *Pyrus calleryana*, on *Ficus macrophylla*, on base of trunk of *Macrozamia communis* in RBG and in Government House gardens. Collected fewer than three times in CC.

Fabronia ?brachyphylla C. Muell. Rose garden near Conservatorium, on base trunk of *Glochidion ferdinandi* and on trunk of *Diospyros digyna*.

Fabronia scottiae C. Muell. Stem of Rosaceous tree, base of *Olea europaea* subsp. *europaea*, trunk of *Ficus macrophylla*, base of trunk of *Macrozamia communis* in Royal Botanic Gardens and on wall near Andrew Charlton Pool in Domain.

Racopilaceae

Racopilum cuspidigerum (Schwaegr.) Aongst. var. *cuspidigerum* Common on pots in nursery, on stonework of Botanic Gardens Creek, on brickwork near nursery, on sandstone near Brown Building, on grass beneath *Liquidambar* and other trees, on brickwork and floor of Cryptogam house, near glasshouses, near Opera House gate, on soil near ponds and on rockface near Andrew Charlton Pool in Domain. Common coloniser of soil.

Ptychomniaceae

Hampeella pallens (Lac.) Fleisch. On bark of the palm *Jubaea chilensis* in garden bed in Royal Botanic Gardens. Mostly found in wet forests as an epiphyte.

Lembophyllaceae

Camptochaete gracilis (Hook. f. & Wils.) Par. [= *Fallaciella gracilis* (Hook f. & Wils.) Crum fide Crum 1991: 313-322]. On trunk of *Ceratonia siliqua* in garden bed between Government House and the Twin Ponds. Occurs mainly in wet forests on rocks.

Hypopterygiaceae

Hypopterygium rotulatum (Hedw.) Brid. On moist sandstone rock near Opera House Gate. Mostly found on wet rocks in valleys and forests.

Thuidiaceae

Thuidium sparsum (Hook. f. & Wils.) Jaeg. Brickwork of Botanic Gardens Creek, brick wall of Pioneer Memorial Garden with *Tortula muralis*, *Bryum dichotomum*, *Fissidens pungens*, *Lunularia cruciata*, Opera House Gate, Government House grounds and on soil and stone walls in the Domain. Common species on rocks and soil in CC. [previously reported as *T. furfurosum* e.g. Scott & Stone (1976) fide Touw & Falter-van den Haak 1989: 1–57]

Leskeaceae

Pseudoleskeopsis imbricata (Hook f. & Wils.) Ther. [*Pseudoleskea imbricata* (Hook. f. & Wils.) Broth.]. Sandstone rock wall and sandstone outcrop in Domain near Mrs Macquaries Chair. Known to occur on calcareous substrates. The calcareous nature of this moss suggests that the sandstone rocks had some calcareous material on the surface.

Amblystegiaceae

+*Amblystegium serpens* (Hedw.) B.S.G. Stone walls of Botanic Gardens Creek. New generic record for CC.

Brachytheciaceae

Brachythecium rutabulum (Hedw.) B.S.G. Glasshouses in Nursery.

Eurhynchium muricatum (Hook. f. & Wils.) Jaeg. Sandstone rocks outside laboratory in Brown Building. Recorded from fewer than three specimens in CC.

+*Kindbergia praelonga* (Hedw.) Ochyra [formerly *Eurhynchium praelongum* (Hedw.) B.S.G. fide Ochyra 1982: 54]. On stone walls of Botanic Gardens Creek and on soil on island near Gardens Restaurant. No report in Ramsay (1984) for N.S.W. but there is a recent record for Sydney by Downing (1989: 6).

Plagiotheciaceae

Rhynchostegium patulum Jaeg. On moist soil in Domain. Previously collected from the area around Port Jackson, Sydney.

Rhynchostegium tenuifolium Hedw. Moist soil with *Racomitrium* on island near Gardens Restaurant. This species occurs on logs and soil.

Sematophyllaceae

Sematophyllum homomallum (Hampe) Broth. On stone walls of Botanic Gardens Creek, epiphytic at base of *Eucalyptus saligna* with *Tortula pagorum*, occasionally on trunk of or rough barked trees e.g. *Jubaea* sp., *Rothmannia globosa* also with *T. pagorum*.

+*Sematophyllum contiguum* (Mitt.) Mitt. Wall of Botanic Gardens Creek, rock in Domain.

Sematophyllum aciculum (Broth. ex Dix.) Dix. Glasshouses near Nursery, in Domain and at Mrs Macquaries Point. Reported from Port Jackson, Sydney.

Hypnaceae

Isopterygium ?minutirameum (C. Muell.) Jaeg. On soil near Depot.

?*Isopterygium albescens* (Hook.) Jaeg. In moist crevices of sandstone rock in Domain toward Mrs Macquaries Point.

In addition there are a number of undetermined sterile pleurocarpous moss species possibly from the families Hookeriaceae and Brachytheciaceae.

2. Annotated species list of hepatics and anthocerotes of the Royal Botanic Gardens, Government House and Domain.

+ not previously recorded for N.S.W.

++ not previously recorded from Australia

Anthocerotes

Anthoceros cf. *punctatus* L. On moist soil outside Ranger's cottage (Victoria Lodge) and on soil (now dug over) near Andrew Charlton Pool in Domain.

Hepatics

Aneuraceae

+*Riccardia bliklika* Hewson. On treefern fibre in orchid glasshouse in Nursery. A Queensland species probably brought in from there.

Riccardia ?macdonaldiana Hewson. Male plants only, on sandstone rock outside laboratory in Brown Building. A Queensland species probably brought in from there.

Pallaviciniaceae

+*Pallavicinia lyellii* (Hook.) Carruth. On stone walls of Botanic Gardens Creek, moist soil near Gardens Restaurant. Not recorded for N.S.W. by Scott (1985) or Scott & Bradshaw (1986).

Metzgeriaceae

Metzgeria decipiens (Mass.) Schiffner & Gottsche. On trunk of tree fern *Cyathea leichhardtiana* near Gardens Restaurant. Recorded as a common epiphyte in wet forest in N.S.W. Probably brought in on the *Cyathea* trunk.

Aytoniaceae

Asterella drummondii (Hook. f. & Tayl.) R.M. Schuster. In pot in nursery. Common on soil crusts.

Marchantiaceae

Lunularia cruciata (L.) Dumort. On stone walls of Botanic Gardens Creek, brickwork in Pioneer Memorial Garden, on soil and stonework of steps overlooking Woolloomooloo Bay in the Domain. Common on soil in the Sydney area and throughout N.S.W.

Marchantia polymorpha L. On soil in pots in nursery in RBG. A common weed of glasshouses in N.S.W.

Ricciaceae

Riccia asprella Carring. & Pears. Outside Government House on black loamy soil.

Riccia bifurca Hoffm. Outside Government house on black loamy soil. Occurs on damp loamy soils often under grass in N.S.W.

Riccia cartilaginosa Stephani. Outside Government House on black sandy loam and on moist sandy soil at edge of sandstone rocks in Domain. Found on wet soil in forest clearings in N.S.W.

Riccia aff. *spongiosula* Na Thalang. Outside Government House on black loamy soil.

Occurs in dry, hot regions of N.S.W.

[Note: all the *Riccia* species, which tend to occur in drier areas, may have been brought in as spores with soil].

++Chonecoleaceae

++*Chonecolea doellingeri* (Nees) Grolle. On bark of various phorophytes, e.g. *Olea europaea* subsp. *africana*, *Eucalyptus saligna*, *Pinus roxburghii*, *Quercus cerris*, *Jubaea chilensis*, *Beilschmiedia elliptica* and the trunk of *Macrozamia communis*, on bark of *Ficus macrophylla* and *F. hillii* in the Domain, outside Government House on bark of *Harpephyllum caffrum* and *Eucalyptus robusta*. This is the first record of this family, genus and species from Australia. *Chonecolea* is a native of Brazil, the lowlands of subtropical South America and of subtropical Florida. This species is thriving and is found throughout the RBG. It also occurs in adjacent areas having been collected near St Mary's Cathedral but has not been found on the northern shores of Sydney Harbour. This species may have arrived as a propagule and become naturalised here.

Lepidoziaceae

Kurzia hippurioides (Hook. f. & Tayl.) Grolle. In crevice below moist sandstone rock overhang in the Domain.

Lepidozia laevifolia (Hook. f. & Tayl.) Taylor ex Gottsche et Nees & Lindenb.). On rotting log in rainforest area of RBG.

Geocalycaceae

Chiloscyphus novae-zelandiae (Lehm. & Lindenb.) Engel & Schust. Near Pyramid glass-house at base of fern *Angiopteris erecta*. Generally found on fallen logs in N.S.W. forests.

Chiloscyphus semiteres (Lehm.) Lehm. & Lindenb. [syn. *Lophocolea semiteres*]. On brickwork of Botanic Gardens Creek, base of the fern *Todea barbara* and the palm *Livistona* sp. outside Gardens Restaurant, brickwork of Cryptogam House, outside Government House and on moist sandstone steps and moist soil at edge of sandstone rocks in the Domain. Common as an epiphyte or on fallen logs in forests in N.S.W.

Chiloscyphus sp. Stonework of Botanic Gardens Creek.

Frullaniaceae

Frullania monocera (Hook. f. & Tayl.) Taylor ex Gottsche, Nees & Lindenb. On bark of *Quercus cerris* (tree since removed) in RBG.

Frullania pentapleura Tayl. On bark of various phorophytes e.g. *Fraxinus*, *Quercus*, *Jubaea chilensis* and *Rothmannia globosa*, outside Government House on *Quercus palustris*. Occurs as an epiphyte or on rocks in N.S.W.

Frullania ?probosciphora Tayl. On bark of *Brachychiton rupestre* near statue of Boy with Thorn (Lower Garden).

Codoniaceae

Fossombronina caespitiformis De Not. ex Rabenh. On moist ground amongst mosses below sandstone rocks at edge of Mrs Macquaries Road in the Domain. Common in Eastern mainland Australia including N.S.W..

Fossombronina sp. Sterile material only, unable to be identified to species without spores. On pot in nursery, growing amongst mosses and *Riccia cartilaginosa* at base of sandstone rocks in Domain.

Lejeuneaceae

+*Cololejeunea ?minutissima* (Sm.) Schiffn. On bark of *Liquidambar* near Twin Ponds, bark of *Rothmania globosa* and a rough-barked tree in garden beds near walled section of Botanic Gardens Creek.

Lopholejeunea sp. In glasshouse amongst mosses at base of orchid stems (*Dendrobium* sp.) in pot and tree fern fibre amongst mosses.

Conclusions

The Royal Botanic Gardens provided an interesting site for study of bryophytes, as the area has been subject to disturbance since settlement. The species present include some native locally and possibly continuously present since early settlement days, as well as opportunistic forms that have invaded by dispersed diaspores, and some species imported on soil or with plants.

In this study 95 species of bryophytes (70 mosses, 24 hepatics and one anthocerot) were collected. A wide range of families is represented: 24–25 families of mosses of which 12 are acrocarpous and 12 pleurocarpous; 13 families of hepatics of which 6 are thallose and 7 leafy. The genera with most species are *Bryum* (10 species), *Fissidens* (8) *Campylopus* (5), *Fabronia* (3), *Tortula* (3), *Chiloscyphus* (4), *Riccia* (4).

Taxa present can be grouped according to their life strategies and/or habitat preferences.

1. Colonising opportunistic species mainly on soil include *Bryum dichotomum*, *Ceratodon purpureus*, *Ditrichum difficile*, *Fissidens* spp., *Funaria hygrometrica*, *Racomitrium cuspidigerum*, *Weissia controversa*, *Riccia* spp.,
2. Epiphytic species common in the gardens are *Fabronia* spp., *Tortula pagorum*, *Frullania* sp.
3. Mosses most commonly found on calcareous substrata are *Bryum argenteum*, *Gymnostomum calcareum*, *Pseudoleskea imbricata*, *Tortula muralis*.
4. Colonisers of rocks include *Campylopus* spp., *Dicnemoloma pallidum*, *Ptychomitrium australe*.
5. Aquatic species present are *Fissidens rigidulus*, *Sphagnum cristatum*.

A new record for Australia is the liverwort *Chonecolea doellingeri* (Nees) Grolle (identified by R. Grolle) and a new moss record for New South Wales is *Leucobryum aduncum* Dozy & Molk. (identified by D.G. Catcheside; many specimens which may be this have probably been identified erroneously as *L. candidum*). Species present in other regions of N.S.W. but not previously reported for the Central Coast (Ramsay 1984) include *Amblystegium serpens*, *Bryum rubens*, *B. subapiculatum*, *Kindbergia praelonga*, *Philonotis ?austro-falcata*, *Sematophyllum contiguum*, *Weissia controversa* var. *gymnostoma*. Some species listed as having only one or two collections in CC by Ramsay (1984) include *Fabronia australis*, *Fissidens leptocladus*, *F. rigidulus*, *Tortula papillosa*, *Ptychomitrium australe*. Hepatics not listed for New South Wales by Scott (1985) include *Pallavicinia lyellii*, *Riccardia bliklii*, *R. macdonaldiana*, *Cololejeunea minutissima*.

Species most likely to have been introduced to Australia rather than being native here are *Kindbergia praelonga* (Hedw.) Ochyra (formerly *Eurhynchium praelongum* (Hedw.) B.S.G.), *Leptobryum pyriforme* Hedw. and *Chonecolea doellingeri* (Nees) Grolle.

Acknowledgments

We are grateful to D.G. Catcheside, A.J. Downing, J.R. Spence I.G. Stone, H. Streimann and R. Ireland for assistance with identification of various species and we wish to thank L.A.S. Johnson and the reviewer who provided valuable suggestions for improvement of the manuscript.

References

- Bradley, W. 1786–92. A Voyage to New South Wales. The Journal of Lieutenant William Bradley RN of HMS Sirius. Facsimile reproduction (Trustees, Public Library of New South Wales and Ure Smith: Sydney 1969.)
- Brotherus, V.F. & W.W. Watts (1912). The mosses of Yarrangobilly Caves District, N.S.W.. *Proceedings Linnean Society of New South Wales* 37(2): 363–382.
- Brotherus, V.F. & W.W. Watts (1915). The mosses of North Queensland. *Proceedings Linnean Society of New South Wales* 43: 544–567.
- Burges, A. (1932). Notes on the mosses of New South Wales I. Additional records and description of a new species of *Buxbaumia*. *Proceedings Linnean Society of New South Wales* 57: 239–244.
- Burges, A. (1935). Notes on the mosses of New South Wales II Additional records. *Proceedings Linnean Society of New South Wales* 60: 83–93.
- Burley, J.S. & N.M. Pritchard (1990). Revision of the genus *Ceratodon* (Bryophyta). *Harvard Papers in Botany* No 2: 17–76.
- Catcheside, D.G. (1980). *The Mosses of South Australia*. (Government Printer: Adelaide.)
- Catcheside, D.G. & J.-P. Frahm (1985). Additions to the *Campylopus* flora of Australia. *Journal of Bryology* 13: 359–367.
- Corley, M.F.V. & J.-P. Frahm (1982). Taxonomy and world distribution of *Campylopus pyriformis* (Schultz) Brid. *Journal of Bryology* 12(2): 187–190.
- Crum, H. (1991). A partial classification of the Lembophyllaceae. *Journal of the Hattori Botanical Laboratory* 69: 313–322.
- Downing, A.J. (1989). In Ramsay, H.P. & P.M. Selkirk (eds). *Australasian Bryological Newsletter* 21: 6.
- Forsyth, W. (1899). Contribution to a knowledge of the mosses of New South Wales. *Proceedings Linnean Society of New South Wales* 24: 674–686.
- Frahm, J.-P. (1985). Additions to the *Campylopus* flora of Australia. *Journal of Bryology* 13(3): 359–367.
- Frahm, J.-P. (1987). A survey of *Campylopus* species in Australia. *Journal of Bryology* 14(4): 701–727.
- Gilbert, L. (1986). *The Royal Botanic Gardens, Sydney – a History 1816–1985*. (Oxford University Press, Melbourne).
- Johnson, L. (1986). In Preface to Wilson, E. (ed). *Discovering the Domain*. (Royal Botanic Gardens and Domain Trust: Sydney).
- Obituary, Oct-Dec (1927). Thomas Whitelegge F.R.M.S. *The Australian Museum Magazine* 8(4): 133.
- Ochyra, R. (1982). *Kindbergia* (Brachytheciaceae, Musci), a new name for *Stokesiella* (Kindb.) Robins. hom. illeg. *Lindbergia* 8: 53–54.
- Ramsay, H.P. (1980). The contributions of Rev. W.W. Watts F.L.S. to Australian Botany. *Taxon* 29(4): 455–469.
- Ramsay, H.P. (1984). Census of New South Wales mosses. *Telopea* 2(5): 455–533.
- Ramsay, H.P. & J. Seur (1990). Type specimens of bryophytes in Australia herbaria. Pp. 247–252 in P.S. Short (ed.), *History of systematic botany in Australasia*. (Australian Systematic Botany Society Inc: Collingwood)
- Scott, G.A.M. (1985). *Southern Australian Liverworts*. Australian Flora and Fauna Series Number 2. Australian Government Printing Service, Canberra.
- Scott, G.A.M. & J.A. Bradshaw. (1986). Australian Liverworts (Hepaticae): annotated list of binomials and checklist of published species with bibliography. *Brunonia* 8(1): 1–171.
- Scott, G.A.M. & I.G. Stone (1976). *The Mosses of Southern Australia*. (Academic Press: London).
- Stephani, F. (1889). Hepaticae Australiae 1–3. *Hedwigia* 28: 128–135, 155–175, 257–278.
- Stephani, F. & W.W. Watts (1914). Hepaticae australes. *Journal and Proceedings of the Royal Society of New South Wales* 48: 94–135.
- Stone, I.G. (1984). *Archidium watsii* comb. nov. in Australia. *Journal of Bryology* 13: 153–157.

- Stone, I.G. (1990). *Fissidens* sections Crispidium, Amblyothallia and Serridium and subgenus Pachyfissidens in Australasia: some taxonomic changes and a key to species. *Journal of Bryology* 16 (2): 245–260.
- Stone, I.G. (1991). *Fissidens linearis* Brid. and its synonyms. *Journal of Bryology* 16: 403–405.
- Sydney Botanic Gardens Annual Report (1909). (Government Printer: Sydney).
- Touw, A. & L. Falter-van den Haak (1989). A revision of the Australasian Thuidiaceae (Musci), with notes on species from adjacent regions. *Journal of the Hattori Botanical Laboratory* 67: 1–57.
- Watts, W.W. & T. Whitelegge (1902). Census Muscorum Australiensium. *Journal of the Linnean Society of New South Wales* 27(3): (Supplement) 1–90.
- Watts, W.W. & T. Whitelegge (1905). Census Muscorum Australiensium. *Journal of the Linnean Society of New South Wales* 30(4): (Supplement) 91–163.
- Wilson, E.(ed) (1986). *Discovering the Domain*. (Royal Botanic Gardens and Domain Trust: Sydney).
- Zander, R. (1977). The Tribe Pleuroweisieae (Pottiaceae, Musci) in middle America. *The Bryologist* 80: 233–269.

Manuscript received 5 August 1992

Manuscript accepted 18 May 1993

Mangrove, saltmarsh and peripheral vegetation of Jervis Bay

Peter J. Clarke

Abstract

Clarke, P.J.* CSIRO Division of Fisheries, P. O. Box 94, Vincentia, NSW, Australia 2540) 1993. *Mangrove, saltmarsh and peripheral vegetation of Jervis Bay*. *Cunninghamia* 3(1): 231–254. Studies of the mangrove and saltmarsh vegetation of Jervis Bay were undertaken for inventory and baseline purposes. Vascular plant species composition, distribution and abundance were quantitatively measured. The vascular flora consists of about 140 species, of which 15 are introductions. Nine species are found at or near their distributional limits around Jervis Bay. The major ordination axes are interpreted as elevation and variability in moisture content. Classification of sites produced 12 complexes after fusion of 30 smaller groups. These complexes have the provisional rank of an association in phytosociology and can be recognised on aerial photographs. The area contains a number of species and vegetation types that are rare or absent from other locations in NSW. Jervis Bay is now a reference system against which changes in the distribution and abundance of intertidal vascular plants can be measured. Such information is fundamental to the management of Jervis Bay and other areas of estuarine vegetation in NSW.

Introduction

Mangroves and saltmarshes are plant assemblages that are periodically inundated with seawater and usually grow in waterlogged saline soils. In Jervis Bay, mangrove and saltmarsh plants are mainly found in six estuaries, although smaller pockets occur in minor creeks, lagoons and on rock platforms. General descriptions of the extent and composition of the vegetation are given in Adam and Hutchings (1987), and West (1987). Major mangrove, saltmarsh and seagrass stands have also been mapped by West *et al.* (1985) at a scale of 1:25 000 based on limited ground truthing.

A baseline study of the mangrove and saltmarsh vegetation was initiated in 1987 as a part of a major study of the marine environment in Jervis Bay. Detailed quantitative information on the distribution, abundance and performance of mangrove and saltmarsh vegetation was required as reference or baseline data, so that any change could be detected after developments in the bay. Such detailed data prior to major developments have been generally lacking for many Australian ecosystems.

Measures were made at the assemblage, population and individual levels of biological organisation over a wide range of spatial and temporal scales. This paper describes: 1) the species composition of the vegetation, 2) the distribution of species across environmental gradients, 3) the population structure of the major species, and 4) the assemblage or community patterns.

Study site

Jervis Bay is a circular marine embayment (35° 07'S, 150° 42'E) with a maximum depth of 30 m and a surface area of 102 km². In comparison with other embayments, the c. 400 km² catchment of Jervis Bay is small relative to the surface area of the bay (West

* Present address: School of Biological Sciences, University of Sydney, Australia 2006.

1987). The mangrove, saltmarsh and fringe forests are found in the tidal creeks that enter the bay and in a few instances on rock platforms. The climate is mild with a mean daily temperatures range of 13.6°C to 19.9°C. The mean annual rainfall for Point Perpendicular is 1230 mm, although the mean rainfall was higher from 1986 to 1991 (c. 1500 mm). Rainfall along the Illawarra section of the south coast is several hundred mm higher than that recorded for the far south coast. The tides in Jervis Bay are semidiurnal with a maximum range of about 2.2 m; the range is attenuated in the tidal creeks and inlets. Anthropogenic influences on the mangroves, saltmarsh and fringe forests have been moderate with some historic clearing and draining, currently these influences are limited to occasional incursions by trail bike or four wheel drive vehicles.

Methods

Survey design

Sampling was designed to measure variables over hierarchies of space and time so that estimates of spatial and temporal variance could be made (see Underwood 1991). In the case of long-lived mangrove and saltmarsh plant species, the survey was designed to assess spatial variation in the distribution and abundance of mangrove and saltmarsh species. Six tidal inlets were sampled in Jervis Bay: Cararma Creek; Wowly Gully; Callala Creek; Currumbene Creek; Moona Moona Creek; and Flat Rock Creek (Figure 1). Each inlet was divided into 500 m sections and transects were randomly placed in these sections at right angles to zonation of vegetation. Adjacent to each transect, 50 X 20 m plots were established. These plots were subjectively located at low, mid and high tidal elevations in structurally similar vegetation. Four replicate quadrats of 5 X 5 m were placed within these plots in a random manner (Figure 1).

Species composition and distribution

Floristic lists were compiled from quadrat, transect samples and field reconnaissance. Voucher specimens have been collected for most species and are held by the John Ray Herbarium at The University of Sydney. Identifications were determined by the Royal Botanic Gardens, Sydney. Nomenclature follows that used by Jacobs and Pickard (1981) and Harden (1990, 1991).

Estimates of cover for each species present in quadrats were made in the following classes: 1 (less than 5%), 2 (5–20%), 3 (21–50%), 4 (51–80%), 5 (81–100%). In order to obtain information on the structure of mangrove communities, *Avicennia marina sensu lato* was divided into five classes based on information about tree height and shape. These classes (attributes) were: seedlings; shrubs <2 m; shrubs 2–5 m; single-stemmed trees >5 m; and multi-stemmed trees >5 m. Measures of cover were initially made from December 1988 to February 1989. A random subset of plots in four creeks was resampled from April to July in 1991 so that temporal comparison of species richness could be made. These data were analysed in a mixed ANOVA where time, creeks, and plots nested in creeks were treated as random factors, but elevation was treated as a fixed factor.

The presence/absence of plant species along each transect was also recorded at contiguous one metre intervals. These data were summed for ten metre lengths of each transect to provide frequency data for interpretation of aerial photography. Data for each creek were summed to provide an overall view of the most common species in

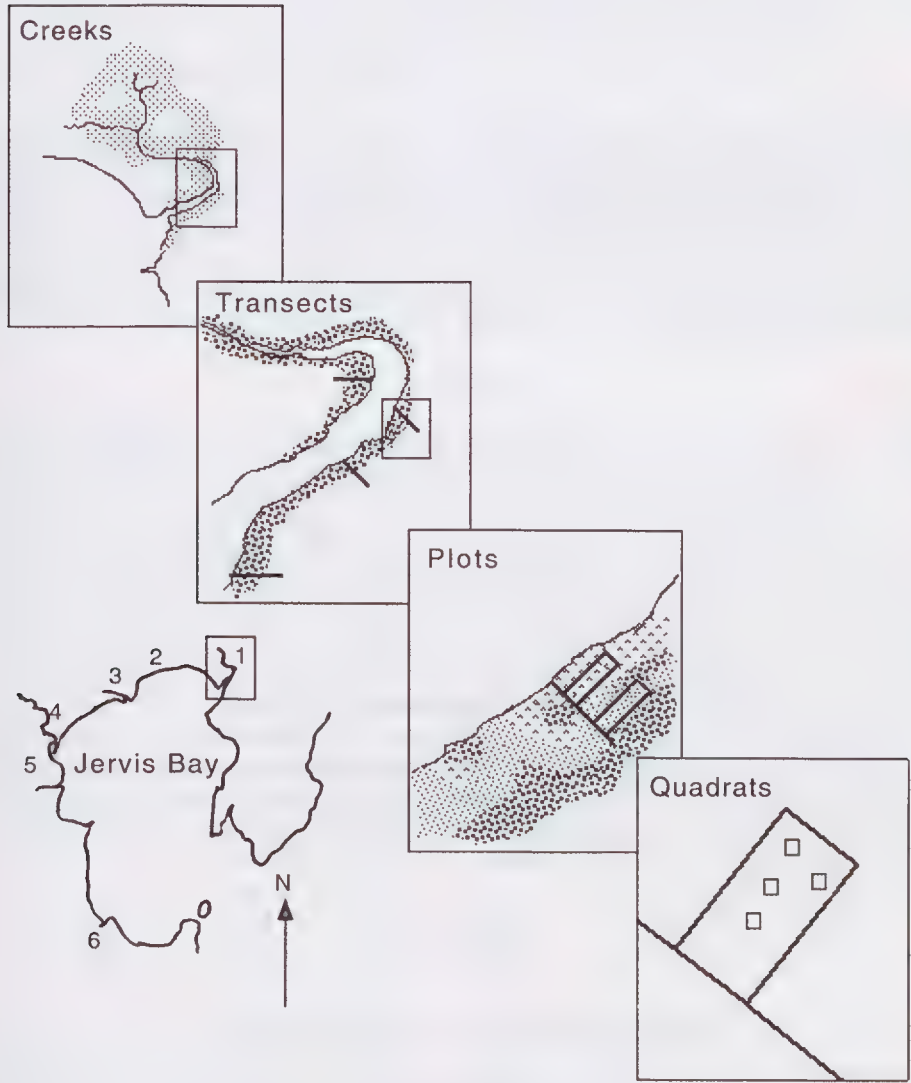


Figure 1. Diagrammatic representation of spatial hierarchies of sampling.

Jervis Bay. In addition to the summed transect data, finer resolution data were collected along four transects in both Carama Creek and Moona Moona Creek. For each of these transects, the presence of species and the ground elevation were measured at one metre intervals.

Population measures

The density, height and girth of species that were common and could be counted as genets were recorded in the same stratified manner as the multivariate data. Subsets of these data were selected for balanced univariate analyses. Nested analyses of variance (ANOVA) were performed for each variable measured on each species; all spatial factors (plots, transects and creeks) were treated as random factors. Data were tested for homogeneity and no transformations were required. The skewed distributions of some data were not normalised as in most cases they were unimodal.

Ordination and classification of plant communities

Ordination and classification was performed only on quadrat data collected from the 1988–1989 samples (412 quadrats). Both sites (objects) and species (attributes) were classified into groups using a polythetic hierarchical divisive classification (TWINSPAN, Gauch 1982), and agglomerative hierarchical classification using the Bray–Curtis association measure with flexible UPGMA sorting strategy (PATN, Belbin 1987). The gradational nature of these data was explored through ordination and direct gradient (transect) analysis. Indirect gradient analysis using hybrid non-metric multidimensional scaling was used to ordinate the site data (Faith *et al.* 1987).

Mapping

Maps of the major plant community types were prepared from enlarged black and white aerial photography. Colour infra-red photographs were taken in January 1989 from a height of 2286 m (scale 1:15 000) by the NSW Land Information Group. The photographic prints were examined and selected frames were enlarged and rectified to 1:4 000 scale by the Australian Land Information Group. Boundaries of the main vegetation types were drawn onto clear film overlays with a 0.35 mm drafting pen. Boundaries were determined using an iterative process of comparing: (1) structural differences on the enlarged images; (2) tonal differences on the enlarged images; (3) colour differences on contact prints; (4) ground transect data; and (5) general ground reconnaissance. Delineation of patchy mangroves proved difficult so canopy gaps were drawn only where they exceed four metres in circumference on the ground. The clear film overlays were subsequently scanned and the digital data reduced to vectors for data management in a GIS and for cartographic output. Copies of the maps are not reproduced here, but will be archived in the library at the Royal Botanic Gardens, Sydney, and the library of CSIRO Division of Fisheries, Hobart.

Results

Species composition and distribution

The seagrass, mangrove, saltmarsh and fringe flora of Jervis Bay contains at least 140 species of vascular plants (Appendix I). The mangrove and saltmarsh vascular flora consists of about 38 species, of which five are exotic. The fringe forest flora is more diverse, containing 80 species with 11 introductions. About 103 species of vascular plants were recorded in transects and 65 species were recorded in quadrat samples.

Nine vascular plant species have been found at or near their geographical limits of distribution in Jervis Bay. Their distribution and population status, based on general observations, are briefly outlined (Table 1) which shows the concentration of these species in the Cararma Creek and Wowly Gully saltmarshes.

Differences in species richness in 5 X 5 m quadrats were detected among plots, elevations and creeks, but not among combinations of space and time (Table 2, Figure 2). Significant differences were detected across time, but the magnitude of the difference, (less than one species) was so small that it seemed to be of little biological importance.

Caution should be used in comparing summed frequencies for common species across different creeks because no statistical comparisons of frequencies within or between creeks have been performed. The relative abundance, however, indicates changes in species dominance among creeks (Figure 3a-f). Summed data for all creeks provided an overall view of the relative composition for all transects in Jervis Bay (Figure 3f), and indicates that the saltmarsh graminoids were predominant at sites sampled.

Table I Estimates of abundance of saltmarsh species of biogeographic interest in Jervis Bay. + = populations with < 100 plants or < 100m² cover, ++ = populations 100–1000 plants or 100–1000m², +++ = populations >1000 plants or > 1000m². A = Cararma Creek, B = Wowly Gully, C = Callala Creek, D = Currambene Creek, E = Moona Moona Creek, F = Other Locations

Species	A	B	C	D	E	F
<i>Atriplex cinerea</i>	+	-	-	-	-	+
<i>Cuscuta tasmanica</i>	-	++	-	-	-	-
<i>Disphyma clavellatum</i>	-	-	-	-	-	+
<i>Distichlis distichophylla</i>	-	++	-	-	-	-
<i>Gahnia filum</i>	+++	++	+++	+	++	+
<i>Limonium australe</i>	+	-	++	-	+	-
<i>Sclerostegia arbuscula</i>	+++	-	-	-	-	-
<i>Stipa stipoides</i>	+	-	+	+	+	++
<i>Wilsonia backhousei</i>	++	+++	+++	-	+	+

Table II ANOVA for species richness in Jervis Bay

Source	df	MS	F denom.	F	P
Year	1	6.828	Residual	6.26	**
Creek	3	32.58	Plot(C)	3.67	**
Y x C	3	6.70	Y x E	0.74	ns
Elevation	2	386.30	C x E	23.99	***
Y x E	2	2.99	Residual	2.74	ns
C x E	6	16.10	Plot(C)	1.81	ns
Plot(C)	36	8.87	Residual	8.13	***
Residual	330	1.09			

n.s. not significant, ** P < 0.01, *** P < 0.001

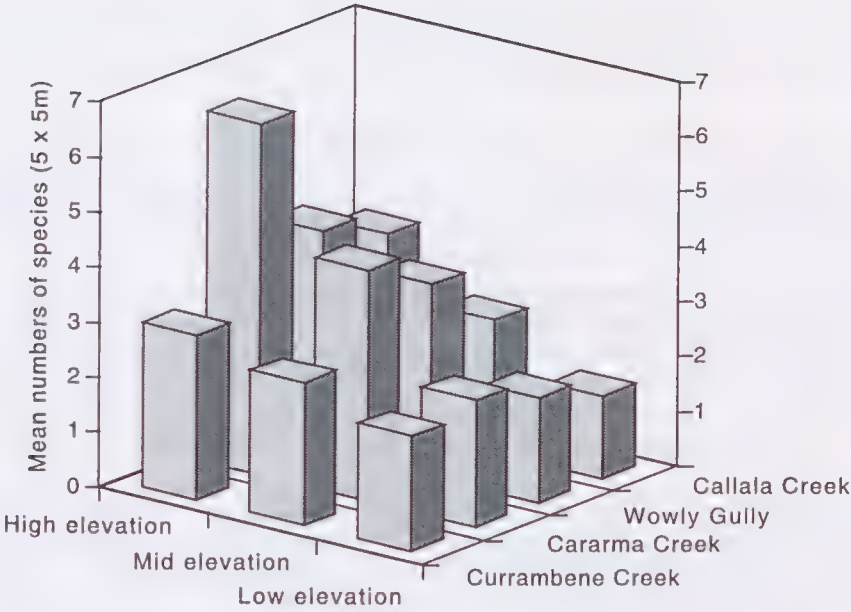


Figure 2. Mean species richness in 5 X 5 m quadrats across four creeks and three elevations in Jervis Bay.

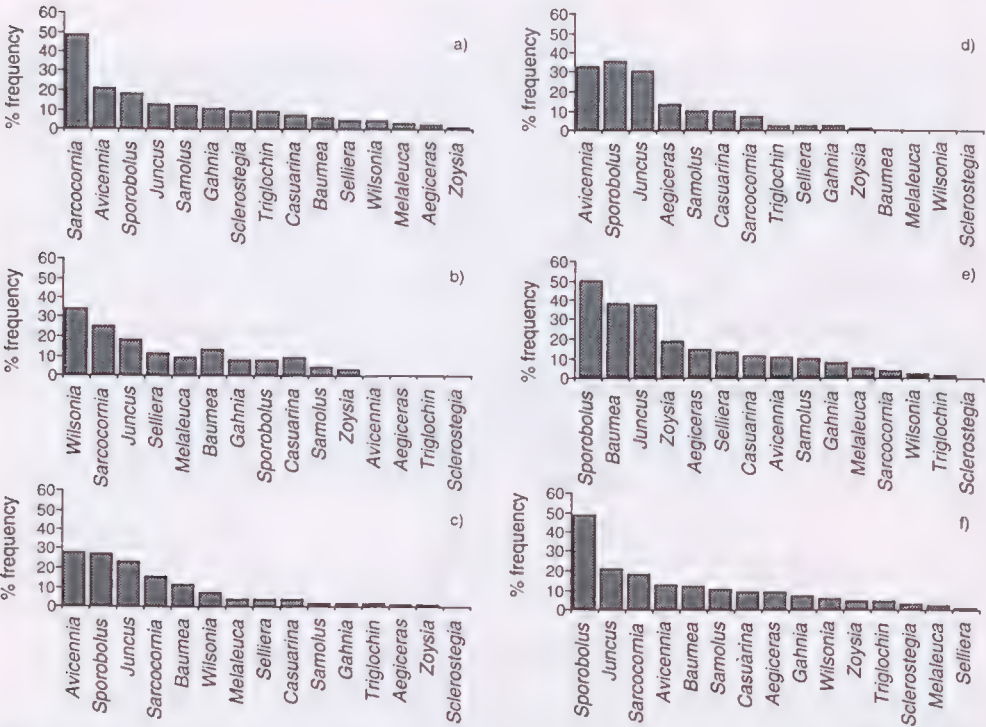


Figure 3. Percent frequency of the 15 most common species found in transects in a) Cararma Creek, b) Wowly Gully, c) Callala Creek, d) Currambene Creek, e) Moona Moona Creek, and f) summed for all creeks sampled in Jervis Bay.

Fine resolution transect data for two transects in each of Carama Creek and Moona Moona Creek are shown (Figure 4a-d) and indicate the gradational nature of the mangrove-saltmarsh-fringe forest zonation.

Table III Summary ANOVA results for population measures of: D = density, H = height, S = seedlings, St = stems, G = Girth. *Av* = *Avicennia marina*, *Ae* = *Aegiceras corniculatum*, *Ca* = *Casuarina glauca*, *Ga* = *Gahnia filum*, *Sc* = *Sclerostegia arbuscula*,

Factor	<i>Av</i>			<i>Ae</i>			<i>Ca</i>			<i>Sc</i>		<i>Ga</i>
	D	H	S	D	H	St	D	H	G	D	H	D
Creek	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	—	—	n.s.
Plot(C)	***	***	n.s.	***	***	*	*	***	*	**	**	***

n.s. not significant, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Population measures

Two species of mangrove *Avicennia marina* and *Aegiceras corniculatum*, the saltmarsh shrub *Sclerostegia arbuscula* and the tree *Casuarina glauca* could be readily counted and measured as genets. In addition, tussocks of the saltmarsh sedge *Gahnia filum* could be counted. Data from subsets of all plots sampled for *Avicennia*, *Aegiceras* and *Gahnia* were used in nested analyses of variance designed to compare a range of spatial scales. In most cases significant differences were detected at the smallest spatial scale, i.e. among plots (Table 3).

Avicennia marina

Seedling densities in quadrats range from one to more than 100 plants, with the distribution being skewed toward low densities (Figure 5a). Adult and juvenile densities for the same quadrats ranged from 1–56 plants and were also skewed toward low densities (Figure 5b). The height of adult plants ranged from 50 cm to 8 m, although few plants exceeded 5 m (Figure 5c).

Aegiceras corniculatum

The density of shrubs ranged from 1–60 plants in quadrats, and most had at least two basal stems (Figures 6a). Heights ranged from 20–300 cm, with a predominance of plants in the 60–80 cm size class (Figure 6b).

Casuarina glauca

The density of adult trees ranged from 1–20 plants in quadrats (Figure 7a). Heights ranged from 1–16 m and were approximately normally distributed (Figure 7b). In contrast, basal girth was skewed towards the smaller size classes, ranging from 10–120 cm (Figure 7c).

Sclerostegia arbuscula

The density of shrubs ranged from 1–40 plants in quadrats of (Figure 8a), with heights from 10–120 cm (Figure 8b).

Gahnia filum

The density of tussocks in quadrats ranged from 1–20 and was strongly skewed toward low densities (Figure 9).

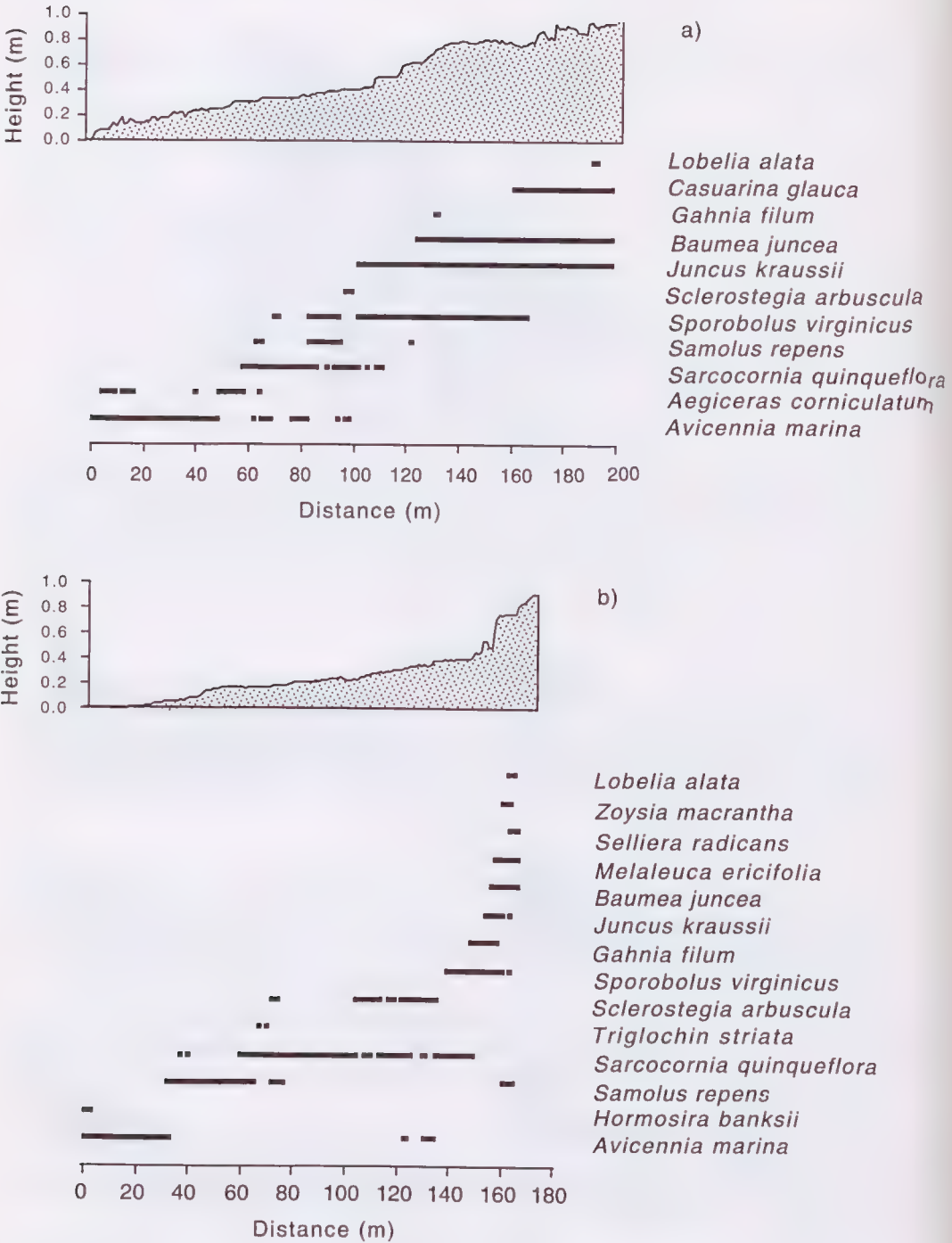
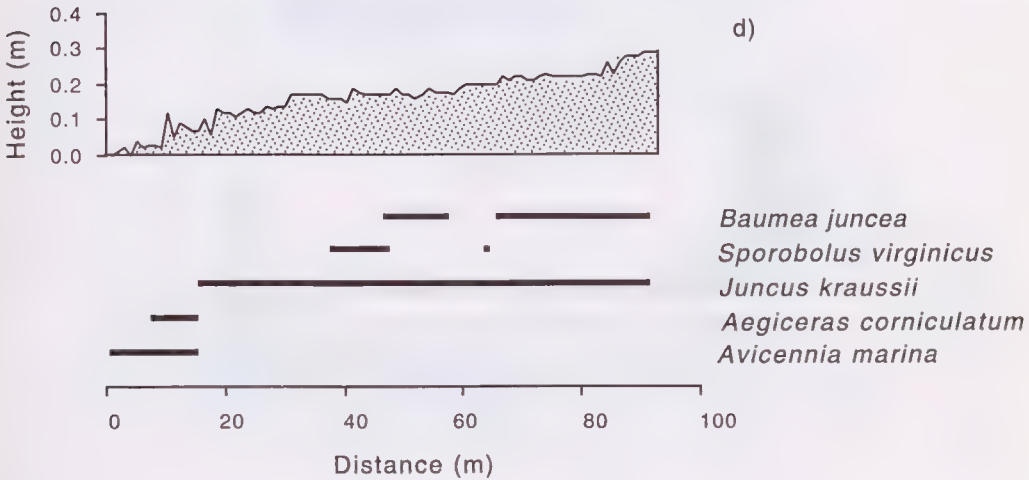
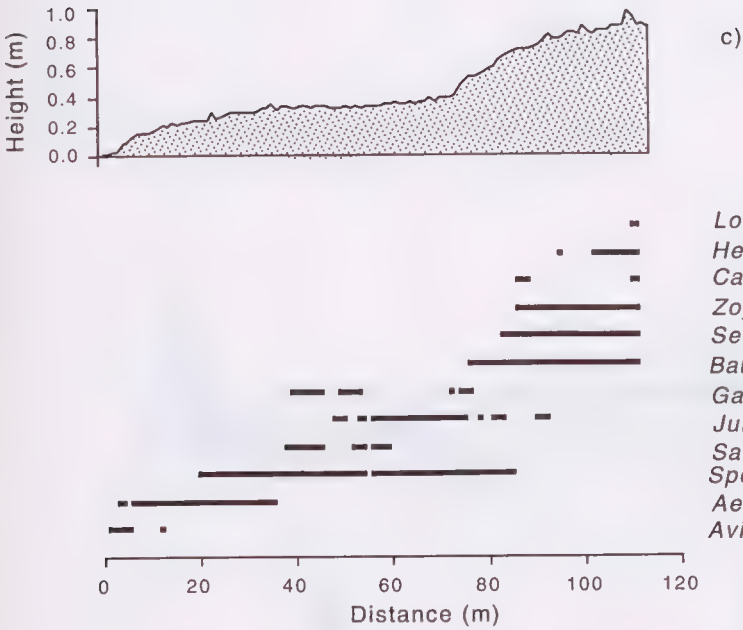


Figure 4. Distribution of plants and height above Australian Height Datum along two transects in Carama Creek (a, b) and Moona Moona Creek (c, d).



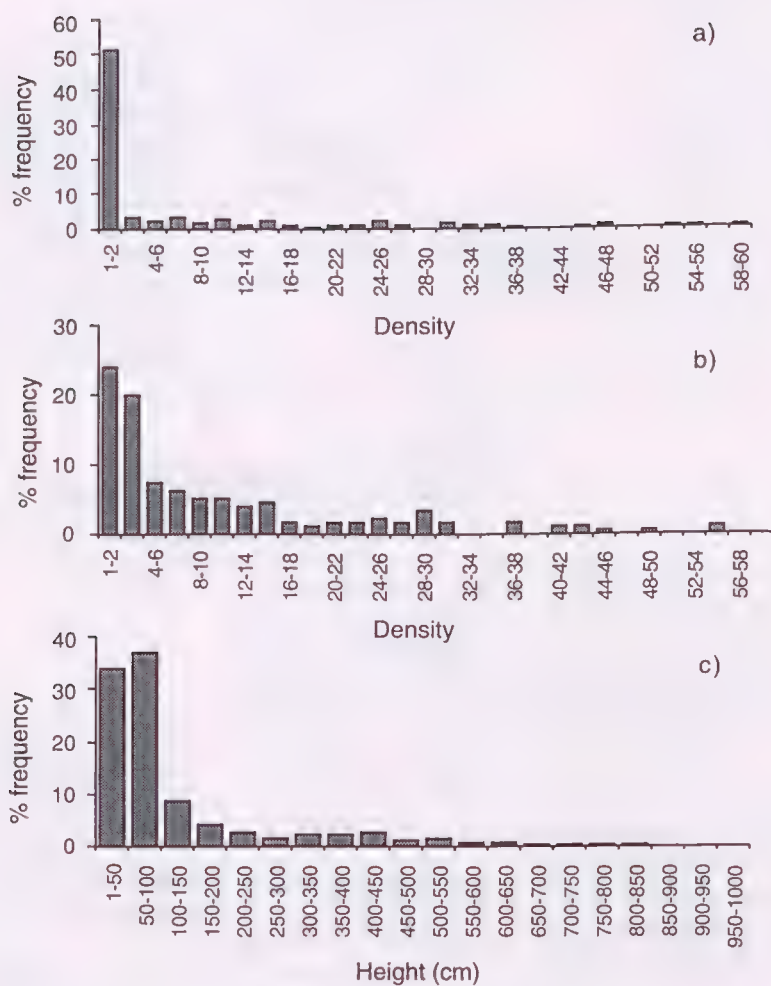


Figure 5. Percent frequency of population measures for *Avicennia marina* a) seedling density (n = 172 quadrats), b) juvenile and adult density (n = 172 quadrats), c) juvenile and adult height classes (n = 1863 stems).

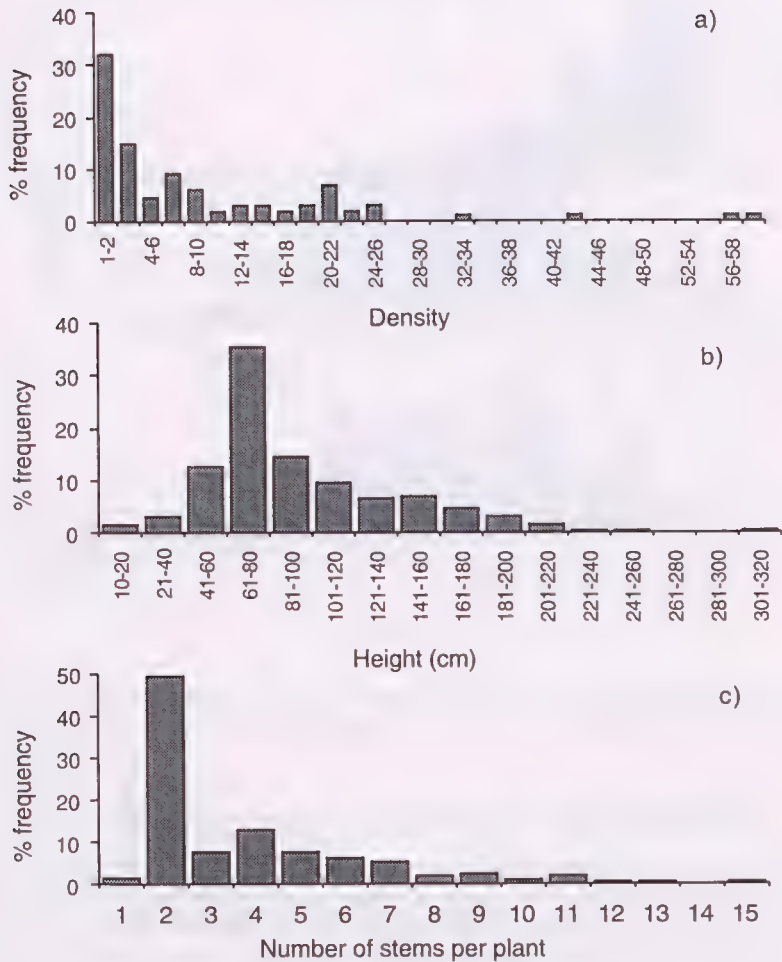


Figure 6. Percent frequency of population measures for *Aegiceras corniculatum* a) adult density (n = 88 quadrats), b) adult height classes (n = 1045 shrubs), c) adult stems per genet (n = 1045 shrubs).

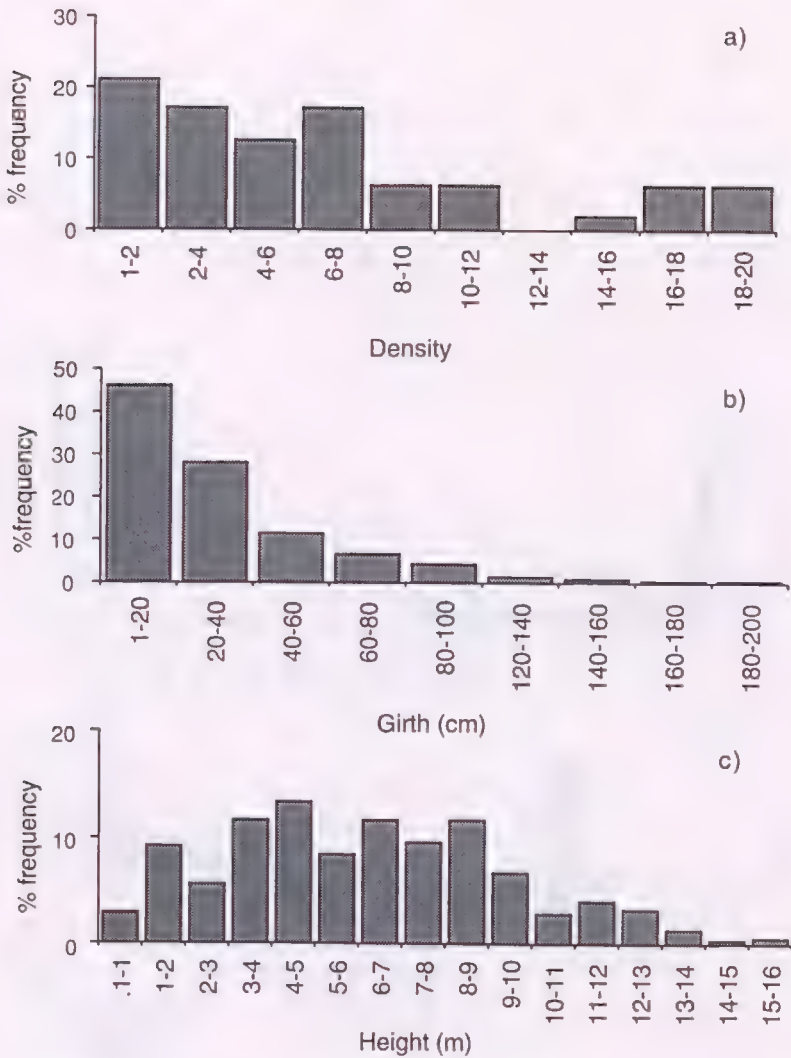


Figure 7. Percent frequency of population measures for *Casuarina glauca* a) adult density (n = 48 quadrats), b) basal girth classes (n = 340 trees), c) height classes (n = 346 trees).

Ordination and classification of plant communities

The ordination of site attributes showed a pattern across two major ordination axes that can be correlated with two broad environmental gradients (Figure 10). Both divisive and agglomerative classification methods produced the same overall pattern of classification although the level at which dendrograms defined similar groups was different. At the finer group level, the agglomerative method produced groups that were intuitively recognisable as patches that could be discerned in the field. Initial analysis erected some 30 groups and these were subsequently fused in 12 complexes (Figure 11), that have the equivalent rank of an association in phytosociology. Smaller sub-groups have the status of a sub-association. A constancy table of the relative

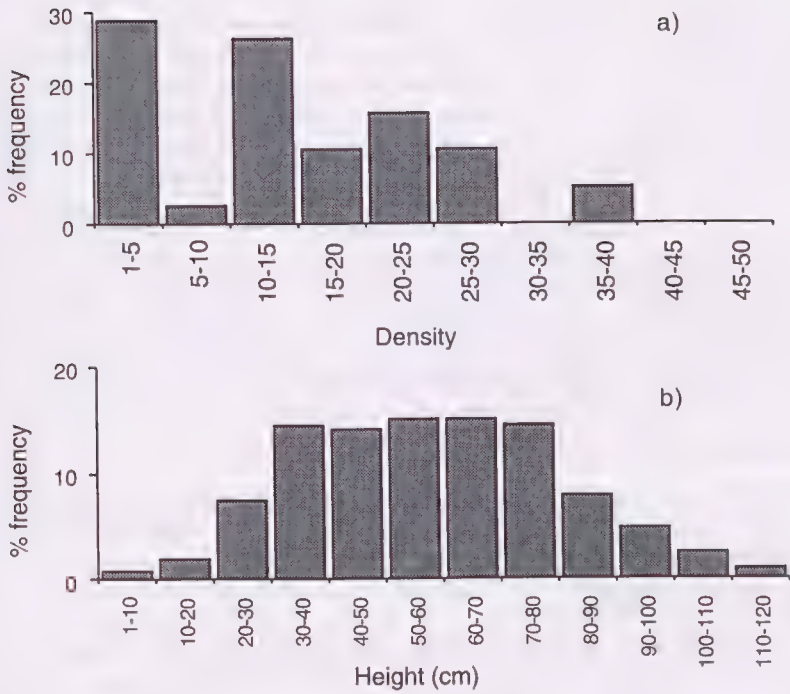


Figure 8. Percent frequency of population measures for *Sclerostegia arbuscula* a) adult density (n = 38 quadrats), b) height classes (n = 509 shrubs).

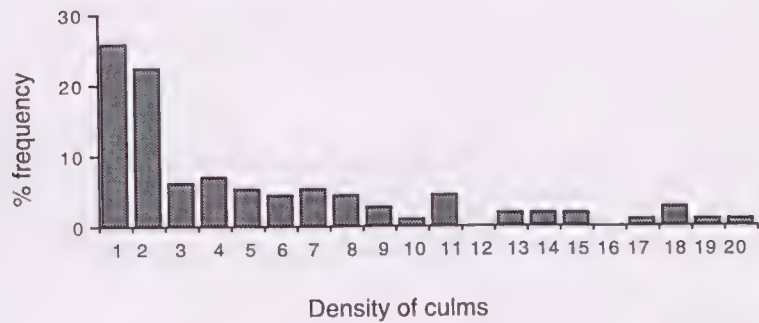


Figure 9. Percent frequency of the density of *Gahnia filum* (n = 116 tussocks).

occurrence of species in complexes and in the sub-groups is shown in Appendix II together with the number of quadrats sampled and species richness in quadrats.

***Avicennia* complex (A)**

The *Avicennia* complex was found in the four major creeks entering the Bay and extended from about Mean Sea Level (MSL) to 50 cm above MSL. Physiognomically, the complex ranged from forests of single-stemmed trees with a closed canopy to low open shrublands. Floristic variation was limited to associated algal species, which were not included in the analysis, and the occasional saltmarsh plant found as a ground cover. Free living (unattached) *Hormosira banksii* commonly occurred as a ground cover in the lower intertidal. Four structural sub-groups have been defined: A1) single-stemmed stands of *Avicennia marina* that formed woodlands or dense thickets where recent accretion had occurred. *Aegiceras corniculatum* often formed a scattered understorey in more open situations; A2) multi-stemmed stands of *Avicennia marina* with occasional canopy gaps were common in most creeks and generally had an abundant seedling understorey; A3) multi-stemmed stands of *Avicennia marina* with open canopies allowed the growth of saltmarsh plants in canopy gaps. The main species were *Sarcocornia quinqueflora*, *Sporobolus virginicus* and *Samolus repens*; A4) low shrubland of *Avicennia marina*, was usually found behind taller stands on hypersaline flats adjacent to saltmarsh, but it also occurred on rock platforms in sheltered parts of the bay.

***Aegiceras* complex (B)**

Shrublands of *Aegiceras corniculatum* were found at higher elevation toward the back of the *Avicennia* complex in the seaward sections of creeks, although there were also dense thickets along the creek banks in Currambene Creek.

***Sclerostegia* complex (C)**

Open shrublands dominated by *Sclerostegia arbuscula* with an understorey of *Sarcocornia quinqueflora* were found only in Carama Inlet. Two sub-groups were evident from classification analysis: C1) Bispecific stands of *Sclerostegia* and *Sarcocornia* with the alga *Chaetomorpha capillaris* as a ground cover; C2) *Sclerostegia* and *Sarcocornia* intermingled with *Avicennia* shrublands at lower elevations.

***Sarcocornia* complex (D)**

Extensive herbfields dominated by *Sarcocornia quinqueflora* occurred in most areas and were gradational with several complexes. They commonly occurred at about the 1.4–1.5 m tide level in the saltmarsh although an extensive sward was also found on the southern side of Bowen Island above high water. Two sub-groups could be distinguished in the analysis: D1) monospecific herbfields of *Sarcocornia quinqueflora*; D2) herbfields dominated by *Sarcocornia* associated with *Triglochin striata* which were found in depressions and at the edges of ponds.

***Sporobolus* complex (E)**

Grasslands forming the *Sporobolus* complex were generally found on well-drained soils in the saltmarsh. This vegetation was also found along the southern cliff tops of Bowen Island. Two sub-groups were distinguished: E1) monospecific grasslands of *Sporobolus virginicus* of variable cover; E2) mixed grasslands of *Sporobolus* and *Sarcocornia*.

***Samolus* complex (F)**

Herbfields dominated by *Samolus repens* were mainly found in the lower saltmarsh where they were often shaded by mangroves. Two sub-groups were described on the

basis of field observations: F1) monospecific patches of *Samolus* were found in shady areas adjacent to mangrove open woodland and were often extensive enough to be mapped; F2) mixed areas of *Samolus*, *Sarcocornia* and *Sporobolus* that intergraded with the *Sarcocornia* complex.

Wilsonia complex (G)

Saltmarsh with a constant presence of *Wilsonia backhousei* formed extensive areas in Wowly Gully and in Callala Creek at about the level of spring tides. *Wilsonia* was also occasionally found on sheltered rock platforms at Cabbage Tree Point. Four sub-groups in the complex could be distinguished: G1) monospecific herbfields of *Wilsonia backhousei*; G2) bispecific areas with *Wilsonia* and *Sarcocornia*; G3) mixed herbfields with *Sarcocornia*, *Triglochin* and *Juncus*; G4) mixed tussocky herbfields with *Gahnia filum* in the upper marsh.

Juncus complex (H)

Rushlands dominated by *Juncus kraussii* were typical of the upper saltmarsh in most localities. Considerable floristic variation occurred within the complex, and three sub-groups were described: H1) dense monospecific stands that were typical of the saltmarsh adjacent to the mangroves in the upper ends of creeks with freshwater runoff; H2) mixed rushlands of *Juncus* and *Sporobolus* which were widespread and occasionally contained scattered shrubs of *Aegiceras*; H3) more diverse areas of mixed *Juncus*, *Sporobolus*, *Gahnia* and *Baumea* which were typically found in the upper ends of smaller creeks.

Baumea complex (I)

Sedgeland dominated by *Baumea juncea* occurred in the upper marsh under the influence of freshwater creeks and groundwater. This complex was transitional between the saltmarsh and fringing forests in some locations. Two sub-groups were described from field observations and classification: I1) monospecific patches of *Baumea juncea*; I2) sedgelands of mixed *Baumea juncea* and *Juncus kraussii*.

Gahnia complex (J)

Tussocky sedgelands dominated by *Gahnia filum* and a ground cover of *Sporobolus* commonly occurred in the transition zone between the saltmarshes and the fringe forests. Three sub-groups of sedgeland were defined: J1) mixed stands with *Sarcocornia* and *Samolus*; J2) mixed stands with *Sarcocornia* and *Juncus*; J3) mixed stands with the tussock grass *Stipa stipoides*, which had a restricted distribution to sandy banks.

Casuarina complex (K)

The swamp oak, *Casuarina glauca*, formed extensive fringe woodlands behind saltmarshes in most localities. Fringe forests were defined as areas that were influenced by saline, waterlogged soils but were dominated by trees other than mangroves. Classification analysis indicated that this complex has close affinities with the saltmarsh and the species, like mangroves, graded from one type to the next. Four woodland sub-groups could be distinguished: K1) *Casuarina* woodlands with an understorey dominated by *Selliera radicans* were mainly found in basin areas; K2) woodlands similar to those described above but with a shrubby understorey of *Myoporum acuminatum* were restricted to Cararra Creek; K3) *Casuarina* woodlands with an understorey of *Sporobolus virginicus* were more common along freshwater creeks; K4) *Casuarina* woodlands with an understorey of *Sporobolus virginicus*, *Zoysia macrantha* and the rush *Juncus kraussii* were also commonly found where there was ground water runoff.

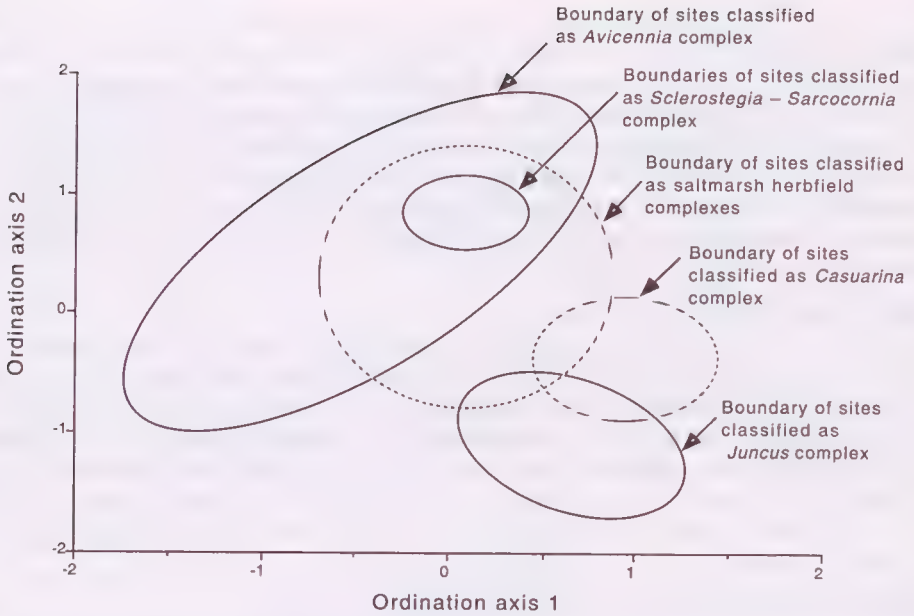


Figure 10 Ordination (hybrid multidimensional scaling) of quadrats simplified to two vectors. Boundaries of major classification groups shown.

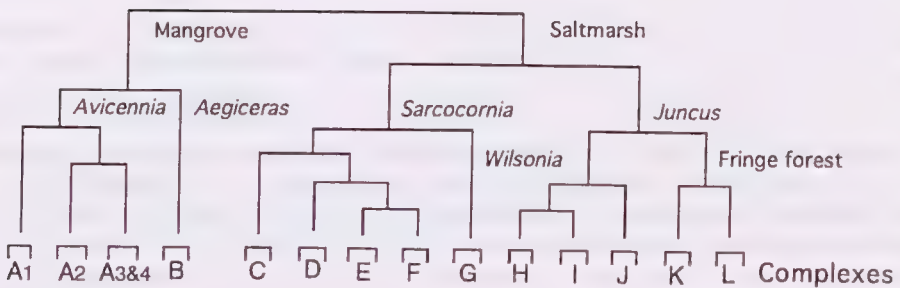


Figure 11 Classification (agglomerative) to the 12 group association level based on vascular plant species and mangrove pseudospecies. Letters correspond to associations described in the text.

Melaleuca complex (L)

Fringing thickets of the shrub *Melaleuca ericifolia* occurred on sandy sediments with some saline influence. Two floristic sub-groups could be distinguished from the analysis although they were mapped as a single complex: L1) thickets of *Melaleuca* occurred as an understorey of *Casuarina glauca* with a ground cover of *Baumea juncea*, *Lobelia alata* and *Hermarthria uncinata*; L2) thickets of *Melaleuca* also occurred as shrublands and graded into *Eucalyptus botryoides* woodland.

Other complexes

Several other complexes also occurred in areas that were infrequently inundated with saline water. However, they were not sampled so the structure and dominant species are only briefly described.

Reedswamps of *Phragmites australis* were common in Currambene Creek, while areas of swamp forest dominated by *Eucalyptus robusta* occurred adjacent to, and graded into, the *Casuarina glauca* forests. Sedgeland of *Cyperus laevigatus* were also found in the shallow, brackish creeks and lagoons at the backs of the beaches that fringe the Bay. The ephemeral and semi-permanent ponds of Cararma Creek supported an unusual submergent, macrophyte vegetation of *Ruppia* and the charophyte *Lamprothamnion*. *Mimulus repens* often colonised the edges of the ponds when they dried out.

Discussion

Species composition and distribution

About 140 species of vascular plants (native and exotic) were found in the mangroves, saltmarsh and fringe forests Jervis Bay. This is approximately half of the recorded flora for saltmarshes in New South Wales (Adam *et al.* 1988). Previous studies of saltmarshes at Lake Illawarra found 127 species (Yassini 1985), while Anderson *et al.* (1981) found 119 species in peripheral vegetation at eight estuaries adjacent to Jervis Bay.

Previous studies have indicated that Jervis Bay contains a number of species that are at their biogeographic limits and, therefore, are of conservation significance (Adam and Hutchings 1987). Several species are at their northern limits in Jervis Bay or have larger populations in Jervis Bay than elsewhere (Table 1). However, the status of saltmarsh plants in NSW is poorly understood and requires further study before conclusions can be made about rarity.

Species richness varied over several spatial scales, but more species were found in the upper saltmarsh than at lower elevations. Differences among creeks were also found; in particular Cararma Creek had consistently higher species numbers in quadrats than other creeks. This may be due the heterogenous physiography of the creek and the relatively undisturbed catchment. Differences in species richness were also detected in time; this was surprising given that all the species were long-lived. On close examination these difference were very small and simply reflect the ability of the sampling design to resolve small differences.

One of the pitfalls in using species richness as a general measure of assemblage trends is that species composition may change without affecting richness. Thus, exotic species could displace existing species, and the richness measure alone would not detect this. New methods using similarity measures to assess changes in diversity are currently being developed to address this problem.

Population measures

The density of *Avicennia marina* was highly variable in Jervis Bay at small spatial scales ranging from less than 100 plants ha⁻¹ to 20000 plants ha⁻¹. This range of density is not unusual, as similar variability has been found in Moreton Bay (Dowling 1986) and in other estuaries in south-eastern Australia (Clarke unpub.). Differences in mean density, height and basal girth between plots, (0.1 ha) reflect a high degree of spatial heterogeneity and highlight the difficulty in generalising for creek and bay spatial scales.

Densities of *Aegiceras corniculatum* showed a similar range to that of *Avicennia marina*, although a larger proportion of the population was found in denser patches. Higher densities and taller shrubs than those in Jervis Bay have been reported in Moreton Bay (Dowling 1986). The height of juvenile and adult *Aegiceras corniculatum* ranged from 10 to 350 cm in Jervis Bay, with most plants being between 60 and 80 cm tall. More than 95% of plants measured were multi-stemmed, and the range of variation appears to be the same at all locations. The low stature of *Aegiceras* in Jervis Bay make this species particularly susceptible to hydrocarbon pollutants because photosynthetic surfaces would be exposed. Recovery after such disturbances may be slow as few propagules appear to establish (as noted by Dowling (1986) in Moreton Bay).

Sclerostegia arbuscula has been found in only eight estuaries in southern New South Wales and the population at Cararma Inlet is the most northern and possibly the largest. Densities of *Sclerostegia* in Cararma Creek were highly variable and the average height of the shrubs (60 cm) appears to be less than that found at more temperate latitudes. No seedlings or juvenile plants were seen, although flowers were recorded each year in autumn. Scorching by fire appeared to have killed plants near the edge of the saltmarsh and plants were easily damaged by trampling. However, examination of aerial photographs suggested that the overall populations in Cararma Inlet have been stable since 1944.

Densities of *Casuarina glauca* ranged from 400 to 8000 plants ha⁻¹, and density distributions were less skewed toward low densities than the densities of either *Avicennia* or *Aegiceras*. The ranges of densities and heights of trees appeared to be similar in all locations. Very few seedlings and juvenile plants were found. Observations at Callala Creek and Moona Moona Creek suggested that fire will kill trees if their crowns are scorched, although partially scorched trees appeared to resprout from the base of the stem.

Vegetation ordination and classification

Both direct and indirect gradient analyses clearly showed that mangrove, saltmarsh and peripheral vegetation form continua when sampled and analysed in an unbiased way. The underlying environmental variables that correlated intuitively with these gradients appeared to be elevation and variability in moisture content, although the causal factors controlling the distribution of species are likely to be much more complex. When site classification was superimposed on the ordination, some broad clusters were discernible but smaller units of classification were poorly resolved. This indicated that the ecological variables influencing such patterns are more complex than a simple two dimensional model.

While site ordination showed the gradational nature of the vegetation, the classification of vegetation types was required for description and comparison among other areas of saltmarsh. A critical decision in the process was to select the level in hierarchical classifications at which vegetation units were described. In this study the 30 group level was initially selected and this was fused into 12 units based on subjective judgement and interpretation of ordination diagrams.

The mangrove complexes described in this study have the same floristic composition as the southern Australian associations described by Bridgewater (1989). However, sub-groups are not directly comparable with Bridgewater's because pseudospecies were used in the Jervis Bay study. Outhred and Buckney (1983) used a similar approach in the Hunter estuary but their pseudospecies were based on vigour rather than form. The distribution of *Avicennia* forms seemed to be correlated with sedimentation and salinity: taller, single-stemmed *Avicennia* stands grew on newly accreted substrates, while multi-stemmed trees were found on older sediments. In saltmarshes, *Avicennia* was shorter and stunted, which is interpreted as the influence of higher salinity (Davie 1984). Elsewhere on the south coast of NSW, grazing by cattle can reduce the stature of *Avicennia*. *Aegiceras* shrublands were found at the rear of *Avicennia* at the entrance to the bay in Cararma Inlet and Currumbene Creek. In contrast *Aegiceras* fringed the creek banks in the more brackish sections of creeks. This pattern may be related to patterns of propagule dispersal rather than a growth response to salinity (Clarke and Myerscough 1991).

Of the 25 saltmarsh communities described by Adam *et al.* (1988), about 16 are analogous to complexes found in Jervis Bay during the present study. However, many of the sub-groups in this study, which have equivalent rank to the sub-association of Adam *et al.* (1988) and Bridgewater (1982), have not been described previously. This is not surprising given the lack of information concerning saltmarshes in NSW. The distribution of saltmarsh complexes is thought to be related to the influence of topography on salinity and drainage (Adam *et al.* 1988). This probably gave rise to the zonal patterns seen in Jervis Bay, although such patterns were rarely consistent within or between creeks. Mosaic patterns were also common in areas with cryptic topography and drainage, and these patterns may also have been influenced by interspecific interactions or the actions of fires and herbivores.

The fringing vegetation of saltmarsh in southern Australia has not been fully described or classified. The ground cover beneath the *Casuarina* woodlands and *Melaleuca* thickets in Jervis Bay often consisted of saltmarsh plants. This was particularly evident in the upper sections of Cararma Inlet where mangroves were intermingled with *Casuarina* and *Myoporum*. The boundaries between freshwater wetland and saltmarsh also became diffuse in the upper reaches of some tidal inlets and swamp woodlands the ground cover often contained saltmarsh species.

Conservation

The total area of 'saltmarsh' and 'mangrove' in NSW is estimated to be less than 57 km² and 108 km² respectively (West *et al.* 1985). Consequently, these vegetation formations are of high conservation significance in NSW because of their small area and distribution. Existing conservation reserves in New South Wales of mangrove, saltmarsh, and their associated fringe forests may not adequately protect all assemblage types because the range of variation within the broad terms 'mangrove', 'saltmarsh' or 'fringe forest' has not been adequately documented. Similarly, comprehensive information about species distribution and abundance is lacking and therefore their conservation status is difficult to assess. Detailed studies, such as the Jervis Bay study and those of Adam *et al.* (1988), begin to address these inadequacies.

Jervis Bay contains extensive areas of relatively undisturbed mangrove and saltmarsh vegetation in catchments that have not been severely degraded by urban development and agriculture. These wetlands also contain a number of species and vegetation types that are apparently rare or absent from other saltmarshes in southern NSW. Added to this biogeographic significance is their importance as a reference

system against which future changes can be measured and against which other areas can be compared. The latter, of course, will depend on the preservation of existing wetlands and their catchments. Current zoning as State Environmental Planning Policy 14 Wetlands has, in part, restricted the development of mangroves and saltmarsh wetlands. However, long-term conservation will not be assured until formal conservation reserves are declared and appropriately managed.

Acknowledgments

Mark Fisher, Lani Retter and Gavin Tinning helped with various aspects of the field work and analysis of data. Paul Adam, Charles Jacoby, Peter Myerscough and Trevor Ward provided welcome comments on the manuscript. The Department of Defence supported studies at Jervis Bay as a part of the CSIRO Baseline Studies of Jervis Bay.

References

- Adam, P. & Hutchings, P. (1987) The saltmarsh and mangroves of Jervis Bay. *Wetlands (Australia)* 6(2): 58–64.
- Adam, P., Wilson, N. & Huntley, B. (1988) The phytosociology of coastal saltmarsh vegetation in New South Wales. *Wetlands (Australia)* 7(1): 35–84.
- Anderson, J. R., Storey, K. J. & Carolane, R. (1981) Distribution of sixteen peripheral vegetation communities in eight estuaries on the south coast of New South Wales and a checklist of species. *CSIRO Division of Land Use Research Technical Memorandum* 81/21.
- Belbin, L. (1987) *PATN, Pattern Analysis Package*, CSIRO Division of Wildlife and Ecology.
- Bridgewater, P.B. (1982) Phytosociology of coastal salt-marshes in the Mediterranean climatic region of Australia. *Phytocoenologia* 10(3): 257–296.
- Bridgewater, P.B. (1989) Syntaxonomy of the Australian mangal refined through iterative ordinations. *Vegetatio* 81: 159–168.
- Clarke, P.J. & Myerscough, P.J. (1991) Buoyancy of *Avicennia marina* propagules in south-eastern Australia. *Australian Journal of Botany* 39: 77–83.
- Davie, J.D.S. (1984). Structural variation, litter production, and nutrient status of mangrove vegetation in Moreton Bay. In: *Focus on Stradbroke* (eds. R. J. Coleman, J. Covacevich, and P. Davie) pp. 208–223. Brisbane, Boolarong Press.
- Dowling, R.M. (1986) *The mangrove vegetation of Moreton Bay*. Queensland Botany Bulletin 6, Department of Primary Industries, Queensland.
- Faith, D. P., Minchin, P. R., and Belbin, L. (1987). Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio* 69, 57–68.
- Gauch, H. (1982) *Multivariate analysis in community ecology*. (Cambridge University Press: Cambridge).
- Harden, G.J. (ed.) (1990) *Flora of New South Wales. Volume 1* (NSW University Press: Sydney).
- Harden, G.J. (ed.) (1991) *Flora of New South Wales. Volume 2* (NSW University Press: Sydney).
- Jacobs, S.W.L. and Pickard, J. (1981). *Plants of New South Wales*. (NSW Government Printer: Sydney).
- Outhred, R.K. & Buckney, R.T. (1983) The vegetation of Kooragang Island, New South Wales. *Wetlands (Australia)* 3: 57–70.
- Underwood, A.J. (1991) Beyond BACI: Experimental designs for detecting human environmental impacts on temporal variations in natural populations. *Australian Journal of Marine and Freshwater Research* 42: 569–78.
- West, R.J., Thorogood, C., Walford, T. & Williams, R. (1985) *An Estuarine Inventory for New South Wales, Australia*. Fisheries Bulletin 2, Department of Agriculture, NSW.
- West, R.J. (1987) Littoral and sub-littoral habitats of Jervis Bay. *Wetlands (Australia)* 6(2): 48–57.
- Yassini, I. (1985) Foreshore vegetation of Lake Illawarra. *Wetlands (Australia)* 5(2): 97–115.

APPENDIX 1 Vascular plant species list for the littoral habitats of Jervis Bay. * introduced species

DICOTYLEDONS

Aizoaceae

Carpobrotus glaucescens
Disphyma crassifolium
Tetragonia tetragonioides

Apiaceae

Apium prostratum
Centella asiatica
*Hydrocotyle bonariensis**
Hydrocotyle acutiloba

Apocyanaceae

Parsonsia straminea

Asteraceae

*Aster subulatus**
Brachyscome graminea
Centipeda minima
*Chrysanthemoides monilifera**
*Conyza albida**
Cotula coronopifolia
Leptinella longipes
Eclipta platyglossa
Epaltes australis
Ozothamnus diosmifolius
*Hypochaeris radicata**
Olearia viscidula
Pseudognaphalium luteoalbum
Senecio hispidulus
Senecio lautus
Senecio linearifolius
*Senecio madagascariensis**
Senecio minimus
*Sonchus asper**
*Sonchus oleraceus**
*Taraxacum officinale**

Avicenniaceae

Avicennia marina

Brassicaceae

*Cakile maritima**

Campanulaceae

Wahlenbergia gracilis

Caryophyllaceae

Spergularia sp.B
*Spergularia rubra**
Stelleria flaccida

Casuarinaceae

Casuarina glauca

Chenopodiaceae

Atriplex australasica
Atriplex cinerea
Chenopodium glaucum
Einadia hastata
Rhagodia candolleana

Chenopodiaceae (cont'd)

Sarcocornia quinqueflora
Sclerostegia arbuscula
Suaeda australis

Convolvulaceae

Calystegia soldanella
Cuscuta tasmanica
Dichondra repens
*Ipomea cairica**
Wilsonia backhousei
Wilsonia rotundifolia

Euphorbiaceae

Poranthera microphylla

Epacridaceae

Monotoca elliptica

Fabaceae

Viminaria juncea
Pultenaea dentata

Gentianaceae

Centaurium spicatum

Geraniaceae

Geranium sp.
Pelargonium australe

Goodeniaceae

Goodenia heterophylla
Goodenia ovata
Selliera radicans

Haloragaceae

Gonocarpus micranthus

Lauraceae

Cassytha pubescens

Lobeliaceae

Lobelia alata

Loranthaceae

Amyema cabbagei

Lyrthaceae

Lythrum hyssopifolia

Fabaceae

Acacia longifolia
Acacia Isophorae

Menyanthaceae

Villarsia exaltata

Myoporaceae

Myoporum acuminatum
Myoporum boninense ssp. australe

Myrsinaceae

Aegiceras corniculatum

Myrtaceae

Acmena smithii
Eucalyptus robusta
Eucalyptus sp. aff. *longifolia*
Eucalyptus tereticornis
Leptospermum juniperinum
Melaleuca ericifolia
Melaleuca squarrosa
Melaleuca styphelioides

Oxalidaceae

Oxalis corniculata

Pittosporaceae

Billardiera scandens
Pittosporum undulatum

Plantaginaceae

Plantago coronopus

Plumbaginaceae

Limonium australe

Primulaceae

Samolus repens

Proteaceae

Banksia ericifolia

Ranunculaceae

Ranunculus inundatus

Rubiaceae

Opercularia aspera

Polygonaceae

Rumex sp.

Scrophulariaceae

Mimulus repens

Solanaceae

Solanum pungetium

Stackhousiaceae

Stackhousia spathulata

Violaceae

Viola hederacea

MONOCOTYLEDONS**Amaryllidaceae**

Crinum pedunculatum

Cyperaceae

Baumea juncea
Carex appressa
Carex pumila
Cyperus laevigatus
*Cyperus polystachyos**
Gahnia filum
Gahnia sieberiana
Isolepis cernua

Cyperaceae (cont'd)

Isolepis inundata
Isolepis nodosa
Schoenoplectus validus
Schoenoplectus litoralis

Hydrocharitaceae

Halophila decipiens?
Halophila ovalis

Iridaceae

*Gladiolus gweinzii**

Juncaceae

*Juncus articulatus**
Juncus kraussii

Lomandraceae

Lomandra longifolia

Juncaginaceae

Triglochin procera
Triglochin striata

Orchidaceae

Dendrobium linguiforme
Dendrobium teretifolium

Poaceae

Agrostis billardieri
*Ammophila arenaria**
Cynodon dactylon
Danthonia linkii var. *linkii*
Danthonia setacea
Distichlis distichophylla
Deyeuxia quadriseta
Festuca littoralis
Hemarthria uncinata
Imperata cylindrica
Paspalum vaginatum
Phragmites australis
*Parapholis incurva**
Poa labillardieri
*Polypogon monspeliensis**
*Spartina anglica**
Spinifex sericeus
Sporobolus virginicus
*Stenotaphrum secundatum**
Stipa stipoides
Themeda australis
Zoysia macrantha

Posidoniaceae

Posidonia australis

Restionaceae

Leptocarpus tenax

Ruppiaceae

Ruppia maritima

Zosteraceae

Heterozostera tasmanica
Zostera capricorni/muelleri?

Manuscript received 10 September 1992

Manuscript accepted 18 May 1993

REVIEW

Vegetation survey and mapping in Queensland

V.J. Neldner, *Queensland Botany Bulletin* No. 10, Brisbane: Queensland Department of Primary Industries, 1993, 70 pp.

This is a timely review on the history and current status of vegetation survey and mapping in Australia. It draws on a wide body of literature in examining past and present approaches to vegetation survey and mapping with particular emphasis on the work undertaken by the Queensland Herbarium.

The report summarises the history of plant community classification, sampling methods used to classify vegetation, values and uses of vegetation surveys, limitations of surveys, the problem of mapping scale and future directions including the use of geographical information system (GIS) technology. Many tables complement the text.

The imposition of classification on the complex world of species distributions results in compromise. This compromise was recognised by early workers in this field and is noted in Neldner's paper by way of a quote from a pioneering doctrine on plant community classification by Beadle and Costin (1952):

"Classification is essentially a compromise between the desire to preserve the natural groupings as continuously varying entities and the need to subdivide them for more utilitarian purposes."

This raises the question — what is the appropriate level of homogeneity of species composition to define communities? This is a key question still requiring more research. Yet it is crucial in the reasoning for examining and defining patterns in nature. Scale or intensity of survey relates to this. As Neldner illustrates, with the history of Queensland vegetation mapping, scale has been chosen largely on the basis of available resources. So 1:1 000 000 and 1:250 000 scales have been adopted for most standard mapping except in special circumstances. The principal aim has been to provide an overview. In NSW we are generally mapping at 1:100 000 scale in the east but 1:250 000 scale in the floristically simpler inland areas. Larger scale maps have been produced for reserves or forests. Given current resources committed to regional botanical survey and mapping in Australia, it will be a very long time before the continent is mapped at say the 1:100 000 scale, yet in my experience this is the minimum scale that land use agencies would like to assist them with property, catchment or reserve management. Other agencies would prefer 1:25 000 mapping for particular areas, for example national parks or state forests.

Lengthy discussion is given to fitting data to the different structural/floristic classifications used in Australia. Perhaps an emphasis should be placed on the need to collect and store raw core attribute data so that it can be used by a range of analyses (Bolton 1992).

Neldner makes an observation that numerical floristic classifications are rarely mapped. What we mainly see on vegetation maps are aerial photograph interpretations of vegetation structure with some dominant floristics applied in some cases (largely depending on the quality and scale of the photographs). Several floristic classifications (whether numerical or traditional) may fall under each photo unit and are described in the text of an accompanying paper. With the advent of more sophisticated modelling, predictive maps may become more important in the future but the quantity of data needed to ensure models work may be so great that the costs of acquiring it may prohibit the project being started or finished. Herein lies a dilemma for the plant ecologist — for a given cost you have the option of acquiring much data

over a small area or less data over a larger area. Generally this is solved by relating projects to their purpose and taking into account resources available.

The advent of improved LANDSAT TM imagery with finer levels of resolution has provided an alternative means of coarse scale mapping of less complicated vegetation. This is not successful in complex eucalypt forests on the east coast or tablelands where problems of shadow are encountered and the difference in reflectance of different types of eucalypt forest are small. At this stage LANDSAT cannot replace aerial photographs for vegetation mapping work except for delineating the outer boundaries of forested lands. Such data can be very useful for assisting with ground survey design.

In his discussion on sampling, Neldner could have enlarged on the efficiency of using explicit, well designed, stratified sampling procedures. It has long been appreciated that maximising the number of sampling sites in botanical surveys facilitates better use of exploratory statistical analyses to aid the ecologist in interpreting patterns and query possible determinants of those patterns (for example, McKenzie *et al* (1991).

The problem of dissemination of information is also raised in the report. It pays tribute to this journal for filling a niche by publishing results of vegetation survey and mapping. However, there have been cases in NSW where other Government agencies were unaware of publications relevant to their survey programmes. In some cases this has resulted in duplication of work. With the distribution of index data bases, such as the one being developed for vegetation studies in the Murray Darling Basin, duplication will be minimised in the future.

Another important point canvassed in the report is the possible misuse of digitised vegetation maps or survey data where a third party, who, without the benefit of field knowledge, attempts to draw definitive conclusions from some other person's data. It is likely that this problem will grow with the wider use of GIS. The report rightly raises some fundamental questions for the future, particularly the impact of GIS on vegetation sampling and mapping.

If regional vegetation surveys and mapping have benefits to the tune of 40:1, as suggested by Neldner, it would seem prudent to conduct more surveys throughout Australia. I disagree, however, with the Queensland Herbarium's policy of mapping original vegetation. In NSW we are now concentrating on surveying and mapping existing vegetation cover. Extrapolations to cleared land can be made if observational data is available or modelling is possible but this is seen as a secondary objective.

If carried out under well designed methods, vegetation survey and mapping can form one of the best information bases to assist with the long term management of species and ecosystems and with the rehabilitation of land. There is an urgent need for programs to be accelerated by governments throughout Australia.

References

- Beadle, N.C.W. and Costin, A.B. (1952) Ecological classification and nomenclature. *Proc. Linn. Soc. New South Wales* 77:62-82.
- Bolton, M. (ed.) (1992) *Vegetation: from mapping to decision support*. (Environmental Resources Information Network: Canberra)
- McKenzie, N.L., Robinson, A.C. and Belbin, L. (1991) Biogeographic survey of the Nullarbor District, Australia. In Margules, C.R and Austin, M.P. *Nature conservation: cost effective biological surveys and data analysis*. (CSIRO: Australia)

J.S. Benson
National Herbarium of New South Wales
Royal Botanic Gardens
Sydney, Australia 2000.

Ecology of Sydney Plant Species Part 1

Ferns, fern-allies, cycads, conifers and dicotyledon families
Acanthaceae to Asclepiadaceae

Doug Benson and Lyn McDougall

Abstract

Benson, Doug and McDougall, Lyn (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1993. Ecology of Sydney Plant Species: part 1 — ferns, fern-allies, cycads, conifers and dicotyledon families Acanthaceae to Asclepiadaceae. Cunninghamia 3(2) 257–422. Ecological data in tabular form is provided on 350 plant species, both native and naturalised, occurring in the Sydney region, defined by the Central Coast and Central Tablelands botanical subdivisions of New South Wales (approximately bounded by Lake Macquarie, Orange, Crookwell and Nowra).

Data is derived from herbarium collections, literature and field observations. It is hoped that the many, often alarming, gaps in the information available will stimulate much-needed research into the ecology of more of the species. Information is provided so far as available to us for each plant species in the following categories:

Life history: Growth form, vegetative spread, longevity, primary juvenile period (time from germination to fruiting), reproduction, flowering and fruiting times, fruit/seed type, dispersal, establishment and growth, fire response, interaction with other organisms.

Distribution: Status/origin (native/naturalised), botanical subregions, distribution in Sydney area, selected locations.

Habitat: Habitat, altitude, annual rainfall, typical local abundance, vegetation, substrate, exposure.

Conservation: Conservation status.

Introduction

Conventional botanical floras and handbooks provide descriptions useful for identifying species, but give relatively little ecological and biological data. Similarly the wide range of illustrated plant books and those aimed at the gardener may give the impression that much is known, but in fact provide mainly plant descriptions with some broader information on plant growth and propagation. Very little of this helps us to understand the plant and its behaviour in its natural habitat. Yet such information is becoming increasingly relevant for natural area managers, who have the task of trying to predict the ecological consequences of different bushland management practices, for people involved in bush regeneration, land rehabilitation and landscape design, for researchers in many fields and for a wide range of people who are interested in bushland and native plants. Species-specific information is also necessary for environmental impact assessment and predicting the effects of changes in drainage, water movement, wind exposure, nutrient conditions and fire regimes on plant species and communities. For example Leishman *et al.* (1992) argue that greater knowledge of seed and seedling biology will be needed if we are to predict changes in species distribution in response to shifting climatic patterns. Fire ecology is an area in which there has been considerable research, and Gill & Bradstock (1992) have recently proposed a national register for fire responses of plant species.

Peter Myerscough, in his 1990 Linnean Society of New South Wales Presidential Address, suggested that attributes of plants be described and compared over all stages of their life cycles to seek relationships between syndromes of plant attributes and ranges of habitats occupied by them. 'Understanding the Australian flora involves, firstly, knowing what plants make it up and where they occur, secondly, knowing their origins in geographical and evolutionary terms, and, thirdly, knowing how they inhabit their respective habitats and interact with other components of their environment. The first two sets of knowledge are being addressed on an institutional basis in herbaria across Australia. The third has yet to be tackled in any organised institutional way.' (Myerscough 1990).

Through *Ecology of Sydney Plant Species* we hope to provide ecological information on Sydney plants, both native and naturalised, with particular emphasis on data that is relevant to ecologists and land-use or conservation managers. This information will be largely complementary to the descriptive texts in taxonomic handbooks such as the *Flora of New South Wales* (Harden 1990–93), and covers growth form, flowering and fruiting times, longevity and maturity periods, pollination and seed dispersal, distribution, habitat and plant community, as well as response to fire and disturbance if data is available. Such information is often difficult to obtain because it is either scattered through various references, both scientific and general, or simply not available in written form, but held in the capacious memories of field and herbarium botanists. Indeed often no-one has noted whether a species resprouts after fire, or how it is dispersed, and much of this data must be compiled anew from direct field observations.

Many gaps will be evident beside headings such as longevity, fire response, exposure and conservation. This reflects our current lack of basic information for many species and we encourage readers to document their own observations both in the field and under controlled conditions. Information about species for inclusion in future parts would be particularly useful and can be sent to the Ecology Section, Royal Botanic Gardens, Sydney.

Methods

For *Ecology of Sydney Plant Species*, the Sydney region is defined as the Central Coast and Central Tablelands botanical subdivisions (i.e. approximately bounded by Lake Macquarie, Orange, Crookwell and Nowra) (Figure 1). This is the area broadly covered by *Flora of the Sydney Region* (Beadle *et al.* 1982), with the exception that the Hunter Valley is not included here since it lies within the North Coast and Central Western Slopes subdivisions.

The Sydney region includes approximately 3500 plant species, both native and naturalised. To deal effectively with this number, the work has been divided into parts each of approximately 350 species, based on plant families beginning with ferns, cycads and gymnosperms, and then dicotyledon and monocotyledon families. Within these groups, families, genera and species are arranged alphabetically:

- Part 1:** Ferns, fern allies, cycads and conifers,
dicotyledon families Acanthaceae to Asclepiadaceae
- Part 2:** Dicotyledon families Asteraceae to Buddlejaceae
- Part 3:** Cabombaceae to Eupomatiaceae
- Part 4:** Fabaceae

Part 5: Flacourtiaceae to Myrsinaceae

Part 6: Myrtaceae

Part 7: Nyctaginaceae to Rubiaceae

Part 8: Rutaceae to Zygophyllaceae

Part 9: Monocotyledon families

Part 10: Monocotyledon families

The project was briefly outlined by Benson (1991). For each species (and generally for subspecies) a data sheet is prepared incorporating life history, distribution and habitat data from specimens in the National Herbarium of New South Wales; this information is entered in a database. To this is added data from literature sources both published and unpublished. References have been cited as appropriate but for unreferenced data responsibility has been assumed by the authors. A provisional compilation sheet with the available information is then prepared and distributed to interested persons for comments and additions/alterations. This compilation will then be published in parts in *Cunninghamia* (beginning with this issue), with the subsequent long-term aim of producing a book at the completion of the ten parts. This will allow the incorporation of new and additional material.

Information Categories

For each species or subspecies, information is presented under headings relating to different life-history aspects, each with further subdivisions. Some slight alterations to categories have been made to reflect the different life cycles of ferns, cycads and conifers, but the general layout is similar to that for other taxa.

Emphasis has been given to understanding the species in its wild habitat. For this reason data on cultivation and artificial propagation, readily available in various horticultural books, is generally not included. Likewise information on weed control is not given. Otherwise, however, the categories are broadly interpreted and since an aim of the project is to stimulate further investigation, we welcome the addition of extra data on any other aspects of the plant's ecology.

Botanical Nomenclature

Family/genus/species: Names currently recognised at the National Herbarium of New South Wales and mostly as used in *Flora of New South Wales*.

Common name: Names currently recognised at the National Herbarium and used in *Flora of New South Wales*.

Life History

Growth form: Brief description

Source: *Flora of New South Wales*

Vegetative spread: Indication of whether localised expansion or spread is possible from an individual by rhizome, stolon rootsucker etc. Important in determining ability of species to colonise immediate local area. Does not include vegetative distance

dispersal which is included under establishment and growth (diaspore).

Source: Flora descriptions, Herbarium specimens, field observations.

Longevity: Average potential life-span under natural conditions — range in years where possible, otherwise short <10 years, medium 10–30 years, long 50 years or more, indefinite, where death is not a result of inherent growth e.g. continued rhizomatous growth. Longevity may be shorter in cultivation.

Source: literature, authors' assessment from field observations.

Primary juvenile period: Time taken from germination to produce first fruits or spores (Gill (1975) uses the term for the period from germination to flowering but the period to fruit maturity is more significant ecologically). Secondary juvenile period is time taken for individual to recover to produce fruit after major damage e.g. from fire, but applicable only if species regularly resprouts.

Source: literature, field observations.

Reproduction: For ferns — nature, time, size etc. of spores; for cycads and conifers — nature of cones, pollination vector, maturation period; for angiosperms, reproduction separated into:

Flowers: Flowering period — range of months and, where possible, peak month based on frequency of herbarium collections. Pollination vectors.

Source: Herbarium specimens, field observations, *Flora of New South Wales*, literature.

Fruit: Fruit shape and size, particularly with respect to potential dispersal agents. Maturation period. Seed size and number.

Sources: Various.

Establishment and growth: Diaspore type including vegetative, dispersal agent. Germination requirements — seedbank presence, dormancy, growth rates, seasonality, deciduousness etc. [notes on propagation in cultivation may be given where these imply similar behaviour under natural field conditions e.g. insights into inhibition of seed germination].

Source: Literature, field observations.

Fire response: General response of mature plant to fire, in particular whether it generally resprouts or is killed (see also Gill 1981, Gill & Bradstock 1992). Seedling recruitment associated with fire is included under Establishment and growth.

Source: Field observations, literature.

Interaction with other organisms: Symbiosis, predators, diseases etc.

Source: Mainly literature.

Distribution

Status/origin: Native or naturalised, region of origin, source and date of introduction/naturalisation.

Source: *Flora of New South Wales*, literature.

Botanical subregions: Occurrence of species in botanical subdivisions of N.S.W., other states and countries.

Source: National Herbarium of New South Wales Census.

Distribution in Sydney area: Main geographic regions occupied by species.

Source: Herbarium specimen records.

Selected locations: Restricted to 10 localities for each taxon reflecting natural geographical range of species in the Sydney area. Earliest collection dates are given for some species, particularly exotic species. Recent collection sites indicated where possible. Locality data must be interpreted carefully. The record may be based on an old specimen or observation record and the species may no longer be present at the site. However a knowledge of the original distribution may be important in showing up particular habitat requirements of the species.

Source: Herbarium specimen records.

Habitat

Specific data refers to the Sydney area unless stated otherwise.

Habitat: Brief generalised description.

Source: Herbarium specimen records, field observations.

Altitude: Approximate altitudinal range (m +/- 100 m) occupied by the species,

Source: Herbarium specimen records.

Annual rainfall: Approximate annual rainfall range (mm +/- 100 mm) for sites occupied by the species.

Source: Bureau of Meteorology (1975, 1979).

Typical local abundance: Most frequent recordings (scale: dominant/frequent/occasional/rare).

Source: Herbarium specimen records.

Vegetation: Main structural type with typical associated species where available.

Source: Herbarium specimen records, field observations, literature.

Substrate: Geology, soil, moisture supply.

Soil nutrient rating scale: very fertile (e.g. basalt soils)/fertile/infertile/very infertile (e.g. sands).

Soil water-table scale: Permanently high/mostly high/mostly low/permanently low

Soil salinity scale: Hypersaline/saline/brackish/fresh.

Source: Herbarium specimen records, field observations, literature.

Exposure: Exposure scale: exposed/indifferent/sheltered.

Shading scale: Deep shade/mid shade/light shade/no shade.

Source: Herbarium specimen records, field observations, literature.

Conservation

Conservation: National significance listing (Briggs & Leigh 1988), regional significance and adequacy of conservation within Sydney area where available.

Source: Herbarium records, field observations, literature.

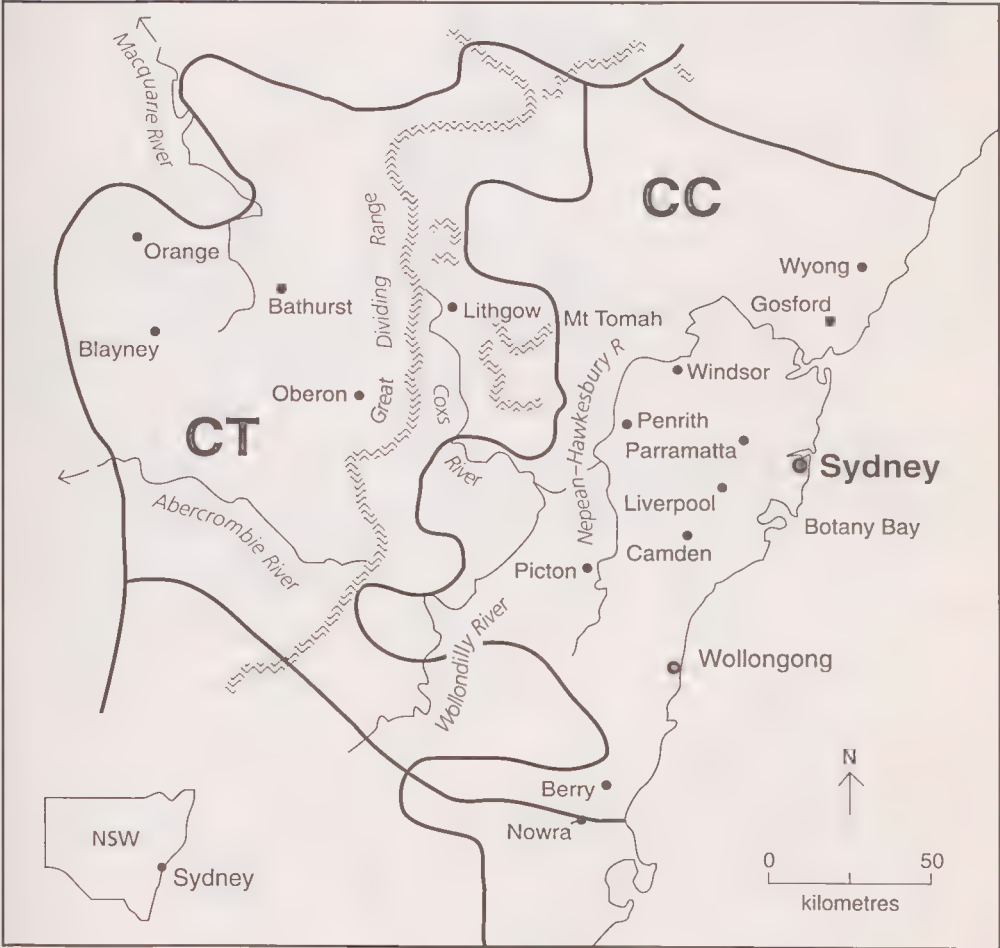
General Comments on Part 1

The majority of Part 1 concerns ferns, gymnosperms and cycads. Many of these species are easily recognised and the ferns in particular have been the subjects of several books (e.g. Jones & Clemesha 1981, Duncan & Isaac 1986). Yet, with the exception of *Pteridium esculentum*, there has been virtually no ecological study of any of these fern species, for

example in regard to dispersal, growth rates or colonising behaviour. Similar comments apply to gymnosperms and cycads and the dicotyledon families. For the latter, data on pollination vectors and dispersal mechanisms are particularly limited. Data on fire responses are available for common, conspicuous species but not for the smaller, less obvious species. Longevity of species, apart from annuals, is rarely noted. The conservation status of many species is unknown. Species where there is most information are generally exotic weeds of concern to agriculture; yet for other exotic species there is virtually no data from local sources; some of these are based on only one or a few old records and may now be extinct in the region.

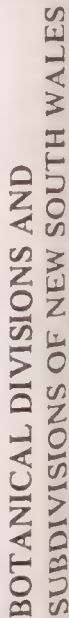
Acknowledgements

The authors wish to particularly thank Paul Adam, Peter Bostock, Barbara Briggs, Elizabeth Brown, Carrick Chambers, Penny Farrant, Ken Hill, Peter Hind, Jocelyn Howell, Surrey Jacobs, Lawrie Johnson, David Keith, Van Klaphake, Phillip Kodela, Peter Lister, Malcolm Gill, John Thomson and Peter Wilson for advice and information and The Royal Botanic Gardens and Domain Trust for financial support.



The Sydney region

For this work the Sydney region is defined as the Central Coast and Central Tablelands botanical subdivisions.



For explanation and description of the Botanical Divisions and Subdivisions of New South Wales see Anderson, R. H. (1961). Introduction. *Contr. New South Wales Natl. Herb. Fl. New South Wales* Nos 1-18, pp. 1-15.

Ferns and Fern Allies

Adiantum aethiopicum

ADIANTACEAE

Common Maidenhair

Life history

Growth form: Terrestrial fern with creeping rhizome.
Vegetative spread: Suckers profusely from underground rhizomes and quickly spreads to a sizeable clump.
Longevity: Indefinite.
Reproduction: Spores produced in sori on lower surface of frond. Spores sporadically throughout the year. Spores 7 months after fire (Bantry Bay, L.McD.). Spore size 30–39 µm (Large & Braggins 1991).
Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very easy to grow in moist semi-protected position but resents total shade (Jones & Clemesha 1981).]
Fire response: Resprouts at ground level. Would be very fire-sensitive in open situations but probably tolerant when rhizomes are amongst rocks (P. Bostock pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS; all states cosmop.
Distribution Sydney area: Widespread, coast and mountains.
Select locations: Gosford, Pennant Hills, Grose Vale, Loftus, Razorback, Mt Wilson, Jenolan Caves, Hill End, Bundanoon.

Habitat

Habitat: Damp open situations, often along creeks.
Altitude: 0–900 m **Annual rainfall:** above 700 mm
Typical local abundance: Frequent–occasional.
Vegetation: Eucalypt open-forest and scrubland, floodplain in tall open-forest with *Eucalyptus saligna*, *Eucalyptus deanei*, *E. clata*, *E. tereticornis*, *Angophora floribunda* or in *Casuarina glauca* low closed-forest.
Substrate: Clay banks and sheltered rock crevices, at the base of cliffs. On shale, sand, limestone & basalt. Soil fertile–infertile, damp, moist. Water table mostly high, moisture supply intermittent, fresh. Possibly salt tolerant, calcium present (P. Hind pers. comm.).
Exposure: Sheltered; light shade (relatively bright, will tolerate full sun if moisture present, P. Hind pers. comm.).

Conservation

Conservation: Adequately conserved e.g. conserved in Western Sydney (Benson & McDougall 1991).

Adiantum diaphanum

ADIANTACEAE

Filmy Maidenhair

Life history

Growth form: Terrestrial fern with $\pm$ erect, condensed rhizome; rootlets with small but prominent tubers (Bostock pers. comm.).

Vegetative spread: Clonal colonies formed by proliferation from root buds (Bostock 1992).

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond.

Spore size 27–40 μm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Dispersal: no special morphology (Westoby *et al.* 1990). Small tubers on the roots store starch (Shinagawa 1962) [Easily grown and will tolerate very dark conditions (Jones & Clemesha 1981).]

Fire response: Likely to be killed (P. Bostock pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT; Qld, Vic., N.Z., Pac. Is, Malesia, China.

Distribution Sydney area: Coast & mountains — rare, (though common further north, P. Hind pers. comm.).

Select locations: Mosman, Como, Austinmer, Sublime Pt, Cambewarra, Minnamurra, Brogers Ck, Mountain Lagoon, Katoomba.

Habitat

Habitat: Sheltered gullies, along streams or near waterfalls in rock crevices.

Altitude: 0–900 m **Annual rainfall:** 1200–1400 mm

Typical local abundance: Rare.

Vegetation: Rainforest.

Substrate: On wet clay banks and dripping rock faces and ledges, on sandstone or shales, infertile soil. Moisture supply continuous, in seepages (P. Hind pers. comm.).

Exposure: Very sheltered, deep shade (P. Hind pers. comm.).

Conservation

Conservation: Rare. Probably not adequately conserved.

Regionally rare in Illawarra region (Mills 1988).

Adiantum formosum

ADIANTACEAE

Giant Maidenhair

Life history

Growth form: Terrestrial fern with fronds 60–120 cm tall.

Vegetative spread: Colonies formed by long-creeping rhizome, often deeply buried, down to 30 cm in loamy soil conditions (P. Bostock pers. comm.).

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond.

Spores at any time. Spore size 23–32 μm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Vigorous & easily grown (Jones & Clemesha 1981) once established, initial establishment difficult (P. Hind pers. comm.).]

Fire response: Probably resprouts (P. Bostock pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT CWS; Qld, Vic., N.Z.

Distribution Sydney area: Coast and Blue Mountains.

Select locations: Ourimbah, Mountain Lagoon, Grose Vale, Ryde, Royal NP, Cambewarra, Minnamurra, Mt Wilson, Blackheath, Bundanoon.

Habitat

Habitat: Moist forest floor, creek banks, hillsides, rocky cliffs.

Altitude: 0–1000 m **Annual rainfall:** 1200–1400 mm

Typical local abundance: Frequent

Vegetation: Rainforest or tall open-forest.

Substrate: Alluvial flats, deep rich soil, basalt, sandstone. Soil fertile, water table mostly high, continuous supply of moisture; can tolerate periodic inundation but not found on soggy areas, good drainage (P. Hind pers. comm.). Non-saline.

Exposure: Sheltered situations, mid shade.

Conservation

Conservation: Conservation status unknown.

Adiantum hispidulum var. **hispidulum**

ADIANTACEAE

Rough Maidenhair

Life history

Growth form: Terrestrial fern with short-creeping rhizome, occasionally or frequently producing stolons (runners).

Vegetative spread: Spread by creeping rhizome and stolons.

Longevity: Indefinite.

Reproduction: Spores any time, peak August. Asexual reproduction (apomixis) leads to $\pm$ stable populations from mutation events. Hence numerous 'forms', some described as varieties e.g. var. *hypoglaucum* Domin and var. *whitei* (Bailey) P. Bostock and at least one described as a species (*A. pubescens* Schkuht) (P. Bostock pers. comm.). Spores produced in sori on lower surface of frond. Spore size 30–44 μ m (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Spores retain viability 10–15 years (Jones 1987). In the right conditions, rhizomes can stand considerable stress (roots deep in cool crevices etc., fronds shrivelled (P. Bostock pers. comm.). [Easy and hardy species to grow (Jones & Clemesha 1981).]

Fire response: Flush of growth from rhizome after fire (P. Hind pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT NWS; Qld, Vic., N.T., N.Z., Pac. Is, Malesia, Afr.

Distribution Sydney area: Coast and Blue Mountains.

Select locations: Howes Valley, Wheeny Creek, Patonga, Pennant Hills, Razorback, Austinmer, Minnamurra, Jenolan Caves, Wentworth Falls, Capertee.

Habitat

Habitat: Often amongst rocks, in crevices, in locally moist sites.

Altitude: 10–1000 m

Annual rainfall: 700–1400 mm

Typical local abundance: Frequent.

Vegetation: Rainforest & tall open-forest. In *Ceratopetalum*-*Doryphora* rainforest at Bundanoon (P. Bostock pers. comm.).

Substrate: Often amongst rocks and in crevices on sandstone and shale soils, fertile or infertile. Water table mostly high, moisture continuous? Non-saline. Drainage good (P. Hind pers. comm.).

Exposure: Sheltered; mid shade (tolerates more light than *A. formosum*, P. Hind pers. comm.).

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).

Adiantum silvaticum

ADIANTACEAE

Life history

Growth form: Terrestrial fern to 1 m high with long-creeping rhizome usually on soil surface.

Vegetative spread: Limited spread.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Slow-growing but hardy (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC CT; Qld.

Distribution Sydney area: North from the Illawarra region, coast & Blue Mountains.

Select locations: Gosford, Mountain Lagoon, Kurrajong, Wentworth Falls, Blackheath, Mt Wilson, Royal NP (southern limit).

Habitat

Habitat: Often along streams and moist cliff faces (and in gullies, P. Hind pers. comm.).

Altitude: 0–900 m

Annual rainfall: 1000–1200 mm

Typical local abundance:

Vegetation: Grows in rainforest; on forest floor with *Lastreopsis* (P. Hind pers. comm.) and *Blechnum*.

Substrate: Rocky areas, sandstone and sandy alluvium and basalt, P. Hind pers. comm.).

Soil fertile. Moisture supply continuous, seepages, non-saline.

Exposure: Sheltered. Deep-mid shade (P. Hind pers. comm.).

Conservation

Conservation: Regionally rare in Illawarra region (Mills 1988).

Conservation status elsewhere unknown.

Asplenium aethiopicum**ASPLENIACEAE****Life history**

Growth form: Terrestrial fern with short-creeping rhizome.

Vegetative spread: Short creeping rhizome perhaps spreading 5–10 cm.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond, in July.

Dispersal, establishment & growth: Diaspore: spores, dispersed by wind, probably no dormancy mechanism. Drops fronds in response to drought (P. Hind pers. comm.).

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld, Vic., W.A., Afr.

Distribution Sydney area: North from Mt Keira (Harden 1990).

Select locations: Watagan Mtns, Colo River Gorge, Boorai Creek, Erskine Creek, (not recorded from Illawarra by Mills 1988).

Habitat

Habitat: On or amongst rocks in sheltered gullies.

Altitude: 0–400 m **Annual rainfall:** above 1000 mm

Typical local abundance: Rare.

Vegetation: Closed-forest with *Backhousia myrtifolia* and *Ceratopetalum apetalum* with *Pyrrosia rupestris* (P. Hind pers. comm.).

Substrate: On or amongst sandstone rocks, soil infertile, water table mostly high, moisture supply intermittent.

Exposure: Mid shade (P. Hind pers. comm.).

Conservation

Conservation: Rare, but most sites are in conservation areas.

Asplenium attenuatum**ASPLENIACEAE**

Simple Spleenwort

Life history

Growth form: Terrestrial fern with erect, tufted rhizome.

Vegetative spread: Plantlet produced on frond ends and large bunches of plants may be linked together (Jones & Clemesha 1981).

Longevity:

Reproduction: Spores produced in sori on lower surface of frond. Spores March, May (limited data).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [In cultivation easily grown and hardy, but slow growing (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Coast, lower Blue Mountains.

Select locations: Gosford (1888), Buralow Creek, Mountain Lagoon, Illawarra–Wongawilli (Mills 1988).

Habitat

Habitat: Usually on damp rocks in shady places or gullies.

Altitude: 0–500 m **Annual rainfall:** above 900 mm

Typical local abundance:

Vegetation: Rainforest along creeks e.g. with *Blechnum ambiguum*, *Blechnum patersonii*, *Microsorium scandens*.

Substrate: Sandstone rocks. Soil infertile. Non-saline conditions.

Exposure: Sheltered situations.

Conservation

Conservation: Regionally rare in Illawarra region (Mills 1988) and elsewhere.

Asplenium australasicum**ASPLENIACEAE**

Bird's Nest Fern

Life history**Growth form:** Epiphytic or lithophytic with erect, stout rhizome.**Vegetative spread:** No vegetative spread.**Longevity:** Long-lived.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing period August.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind; no special morphology (Westoby *et al.* 1990). Probably no dormancy mechanism. [Easily cultivated, easily raised from spores (Jones & Clemesha 1981).]**Fire response:** Probably killed by fire.**Interaction with other organisms:** Host to Leaf Nematodes (*Aphelenchoides* spp.) (Jones & Elliot 1986).**Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT CWS; Qld, Vic., Pac. Is.**Distribution Sydney area:** Widespread — Coast and Blue Mountains.**Select locations:** Calga, Cordeaux Dam, Illawarra (Mills 1988), Albion Park, Blackheath.**Distribution****Habitat:** On rocks or as large epiphytes in trees.**Altitude:** 0–900 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Rare.**Vegetation:** Gully rainforest.**Substrate:** Growing in trees sometimes in the crown and on rocks on shale or basalt soils, fertile—very fertile. Moisture supply intermittent, fresh.**Exposure:** Sheltered; mid–light shade.**Habitat****Conservation****Conservation:** Abundance reduced by plant collectors, current conservation status unknown.**Asplenium bulbiferum subsp. gracillimum** **ASPLENIACEAE**

Mother Spleenwort

Life history**Growth form:** Clumped terrestrial or epiphytic fern.**Vegetative spread:** Develops bulbils on the fronds to form new plants.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing period November–August, spore size 20–28 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily propagated and hardy (Jones & Clemesha 1981).]**Fire response:** Killed by high intensity fire (Chesterfield, Taylor & Molnar 1990).**Interaction with other organisms:** Host to Leaf Nematodes (*Aphelenchoides* spp.) (Jones & Elliot 1986).**Status/origin:** Native.**Botanical subregions:** NC CC SC CT ST; Qld, Vic., Tas., S.A., N.Z.**Distribution Sydney area:** Mainly Upper Blue Mountains.**Select locations:** Mt. Coricudgy, Mt Tomah, Mt Wilson, Mt Irvine, Pennant Hills (1921), Cambewarra (1886).**Distribution****Habitat:** Terrestrial or growing on rocks, trees or treefern trunks.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Occasional.**Vegetation:** Warm temperate rainforest e.g. *Sassafras*–*Quintinia* with little ground cover except ferns — *Leptopteris fraseri*, *Blechnum patersonii*, *Polystichum formosum*, *Lastreopsis acuminata*.**Substrate:** Base of steep rocks or steep banks on basaltic soil, may be sandstone, rarely epiphytic on trunks or *Dicksonia antarctica*. Very fertile soil, well drained. Moisture supply intermittent, fresh.**Exposure:** Sheltered situations in deep shade.**Habitat****Conservation****Conservation:** Regionally rare in Illawarra region (Mills 1988) and probably elsewhere.

Asplenium difforme**ASPLENIACEAE****Life history**

Growth form: Terrestrial fern with stout, erect rhizome

Vegetative spread: Probably none.

Longevity:

Reproduction: Spores produced in sori on lower surface of frond. Sporing time August–December.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC NC; Qld, N.I.

Distribution Sydney area: Headlands — Broken Bay to La Perouse.

Select locations: Barrenjoey Peninsula, Watsons Bay, Bondi/Tamarama, La Perouse.

Habitat

Habitat: In rocky crevices on headlands near the sea.

Altitude: 0–100 m

Annual rainfall: above 1200 mm

Typical local abundance: Rare–occasional.

Vegetation: Ferns in rock crevices e.g. with *Cyrtomium*.

Substrate: Crevices in sandstone cliff faces, permanent moisture.

Exposure:

Conservation

Conservation: La Perouse southern limit, probably inadequately conserved.

Asplenium flabellifolium**ASPLENIACEAE**

Necklace Fern

Life history

Growth form: Trailing, terrestrial fern with short, erect rhizome.

Vegetative spread: A trailing species that forms colonies by rooting and proliferating from the tips of the fronds.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores at any time.

Spore size 45–60 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms: Fronds shown to have significant concentrations of poisonous cyanogenetic glucosides (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS; Qld, Vic., Tas., N.Z.

Distribution Sydney area: Coast and Blue Mountains.

Select locations: Gosford, Neutral Bay, Eastwood, Waterfall, Razorback, Jamberoo, Springwood, Blackheath, Jenolan Caves, Mt Bindo, Robertson.

Habitat

Habitat: Chiefly in damp rock crevices.

Altitude: 0–1100 m

Annual rainfall: above 700 mm

Typical local abundance: Rare–frequent.

Vegetation: Rainforest, including littoral rainforest, or open-forest.

Substrate: Chiefly found in damp rock crevices on sandstone or shale lenses, or basalt or limestone or granite. Skeletal–sandy loam–brown clay soil, infertile–very fertile.

Water table mostly high, moisture supply continuous, fresh. Seepages.

Exposure: Sheltered situations in deep–light shade.

Conservation

Conservation: Probably adequately conserved.

Asplenium flaccidum subsp. flaccidum

ASPLENIACEAE

Weeping Spleenwort

Life history

Growth form: Terrestrial or epiphyte.

Vegetative spread: Often forming large, pendent clumps.

Longevity:

Reproduction: Spores produced in sori on lower surface of frond.

Spore size 21–35 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores, dispersed by wind, probably no dormancy mechanism. [Easily grown (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Qld, Vic., Tas., N.Z., Pac Is.

Distribution Sydney area: Blue Mountains and Illawarra.

Select locations: Mt Coricudgy, Kurrajong, Mt Tomah, Mt Wilson, Lawson, Jenolan Caves, Mt Kembla, Macquarie Pass, Cambewarra.

Habitat

Habitat: Epiphytic on trees, logs or rocks.

Altitude: 0–1000 m

Annual rainfall: above 1200 mm

Typical local abundance:

Vegetation: Rainforest or *Nothofagus* forest e.g. with *Microsorium scandens*, *Pyrrosia rupestris*.

Substrate: Epiphytic or growing on rocks.

Exposure:

Conservation

Conservation: Conservation status unknown.

Asplenium obtusatum

ASPLENIACEAE

Shore Spleenwort

Life history

Growth form: Terrestrial fern

Vegetative spread: Stout, erect, short-creeping rhizome.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond, in August.

Spore size 25–35 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism.

Fire response:

Interaction with other organisms: Very susceptible to slugs and snails in cultivation.

Distribution

Status/origin: Native.

Botanical subregions: CC SC; Vic., Tas., N.Z.

Distribution Sydney area: South from La Perouse (Harden 1990).

Select locations: Kiama (1886) only record.

Habitat

Habitat: Sheltered sites close to the sea.

Altitude: 0–100 m

Annual rainfall: above 1200 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure: Usually in windswept areas amongst rocks close enough to the sea to be covered by saltspray (Jones & Clemesha 1981).

Conservation

Conservation: Northern limit is La Perouse (Harden 1990) but only Sydney Herbarium record for CC is Kiama (1886). Very rare in the area.

Asplenium polyodon**ASPLENIACEAE****Life history**

Growth form: Epiphytic fern, forms with shallowly lobed and deeply incised pinnae.

Vegetative spread: Medium-creeping rhizome.

Longevity:

Reproduction: Spores produced in sori on lower surface of frond. Sporing period March, August–November. Spore size 21–31 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Hardy but slow growing in cultivation (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Qld, N.Z., Asia, Malesia, Pac Is.

Distribution Sydney area: Widespread — Coast and Blue Mountains, rare.

Select locations: Watagan Mtns, Pittwater, Lilyvale, Albion Park, Minnamurra Falls, Mt Wilson.

Habitat

Habitat: Epiphytic or growing on rocks.

Altitude: 0–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Rare.

Vegetation: Rainforest.

Substrate: On rocks, logs or epiphytic on tree fern trunks on basalt soils but also probably sandstone and shale. Soil fertile, non-saline.

Exposure: Sometimes exposed sites.

Conservation

Conservation: Rarely collected, conservation status unknown.

Asplenium trichomanes subsp. quadrivalens**ASPLENIACEAE****Life history**

Growth form: Terrestrial fern.

Vegetative spread: Stout, erect rhizome.

Longevity:

Reproduction: Spores produced in sori on lower surface of frond. Sporing period March–September. Spore size 31–45 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Difficult to maintain in cultivation, seems to need lime (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NT CT ST; Vic., Tas., SA, W.A., N.Z., cosmop.

Distribution Sydney area: Western Blue Mountains.

Select locations: Jenolan Caves, Wombeyan Caves, Abercrombie Caves, Tuglow Caves.

Habitat

Habitat: Limestone rock crevices.

Altitude: above 500 m

Annual rainfall: above 800 mm

Typical local abundance: Rare–frequent.

Vegetation:

Substrate: On limestone, in crevices of rocks, often near rivers or creeks probably indicating locally moist conditions. Fresh water.

Exposure: Sheltered situations.

Conservation

Conservation: Conservation status unknown.

Pleurosorus rutifolius**ASPLENIACEAE****Life history****Growth form:** Terrestrial fern with short rhizome covered with purplish brown scales.**Vegetative spread:** Limited.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond.

Spore size 29–48 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; all States, N.Z.**Distribution Sydney area:****Select locations:** Brooklyn (1991, new record for CC).**Habitat****Habitat:** Cliffs.**Altitude:** 0–500 m (limited data)**Annual rainfall:** above 1200 mm**Typical local abundance:** Rare.**Vegetation:** Cliff-ledge species e.g. *Calandrinia*, *Cheilanthes sieberi*, *Crassula*.**Substrate:** Sandstone rock overhang.**Exposure:****Conservation:** Conservation status unknown.**Conservation****Pleurosorus subglandulosus****ASPLENIACEAE****Life history****Growth form:** Terrestrial fern with short rhizome covered with purplish brown scales.**Vegetative spread:****Longevity:****Reproduction:** Spores produced in sori on lower surface of frond.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in open ground, resents over-watering and high humidity. Drought resistant fronds shrivel but revive with rain (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CT ST NWS CWS SWS NWP SWP SFWP; all states.**Distribution Sydney area:** Jenolan Caves.**Select locations:** (Herbarium specimens not available.)**Habitat****Habitat:** On hillsides, often growing in the shelter of rocks.**Altitude:****Annual rainfall:****Typical local abundance:****Vegetation:****Substrate:****Exposure:** Exposed**Conservation:** Conservation status unknown.**Conservation**

Diplazium australe (Athyrium australe)

ATHYRIACEAE

Austral Lady Fern

Life history

Growth form: Terrestrial fern, tufted, or with a small trunk.

Vegetative spread: Limited vegetative spread.

Longevity:

Reproduction: Spores produced in sori on lower surface of frond. Sporing December–May, peak May. Spore size 27–53 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown but needs protection from slugs & snails (Duncan & Isaac 1986).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC CT ST CWS; Qld, Vic., Tas.

Distribution Sydney area: Coast South of Sydney & Upper Blue Mtns.

Select locations: Otford, Thirroul, Cambewarra, Mt Tomah, Mt Wilson, Jenolan Caves.

Habitat

Habitat: Moist sites.

Annual rainfall: above 1200 mm

Altitude: 0–1000 m

Typical local abundance: Frequent.

Vegetation: Rainforest (Blackwood–Sassafras) and wet eucalypt tall open-forest.

Substrate: Basalt, soil very fertile, damp. Moisture supply intermittent, fresh.

Exposure: Sheltered; deep–mid shade.

Conservation

Conservation: Restricted, conservation status unknown.

Lunathyrium petersenii (L. japonicum)

ATHYRIACEAE

Japanese Lady Fern

Life history

Growth form: Terrestrial fern with short-creeping rhizome.

Vegetative spread:

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores tend to mature all at once on each frond, but the fronds are at different stages so the plant would probably have spores over most of late spring–summer (E. Brown pers. comm.).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Becomes naturalized readily, easily grown (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld, Vic., N.Z.*, Pac, Malesia, Asia.

Distribution Sydney area: Coastal and lower Blue Mountains, rare.

Select locations: Springwood (St Helena), Thornleigh, Minnamurra Falls.

Habitat

Habitat: Rocky places near creeks.

Annual rainfall: above 1100 mm

Altitude: 0–500 m

Typical local abundance: Occasional–rare.

Vegetation: Rainforest and tall open-forest.

Substrate: Probably sandstone. Infertile soil. Moisture supply intermittent, fresh.

Exposure: Sheltered.

Conservation

Conservation: Rare. Regionally rare in Illawarra region (Mills 1988).

Azolla filiculoides var. rubra**AZOLLACEAE****Life history**

Growth form: Small free-floating aquatic fern. Fronds 2-lobed, the upper lobe thick and photosynthetic with a central cavity containing a colony of nitrogen-fixing blue green alga (*Anabaena azollae*).

Vegetative spread:

Longevity: Indefinite. Plants present throughout the year (P. Hind pers. comm.).

Reproduction: Spores in sporocarps. Plants rarely fertile. Spore size 18–27 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: sporocarps, rare — plants usually multiplying by fragmentation. During the spring or in shaded situations the upper parts of the plant are green, whilst in summer and autumn and when exposed to full sunlight they usually become dark red. Plants can double leaf area in 7 days, dense growth usually indicating high nutrient levels (Sainty & Jacobs 1981). [Grows readily in aquaria particularly with a little fertilizer (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms: In Vietnam rice yields have been increased by cultivating *Azolla* in paddy fields. The blue-green alga *Anabaena azollae* in the leaves, fixes nitrogen from the air, which is released as the *Azolla* decays (Sainty & Jacobs 1981).

Distribution

Status/origin: Native.

Botanical subregions: NC CC CT ST NWS CWS SWS NWP SWP SFWP; Qld, Vic., Tas., S.A., N.Z., Amer., Eur.

Distribution Sydney area: Widespread.

Select locations: Kogarah, Macquarie Fields, Gerringong, Wallerawang.

Habitat

Habitat: Mostly found covering the surface of still or slowly moving water.

Altitude: 0–1000 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent.

Vegetation: Open-water wetlands, where there is little wave action.

Substrate: Water table permanently high — mostly found covering the surface of still or slowly moving fresh water.

Exposure: Not in shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).

A. filiculoides more common in NSW than *A. pinnata* (Sainty & Jacobs 1981).

Azolla pinnata**AZOLLACEAE****Life history**

Growth form: Small free-floating aquatic fern in colonies.

Fronds 2-lobed, the upper lobe thick and photosynthetic with a central cavity containing a colony of nitrogen-fixing blue green alga (*Anabaena azollae*). Morphological characters modified by degree of spacing of individuals in the population (Loyal *et al.* 1982).

Vegetative spread: Spreads by fragmentation.

Longevity: Less than 1 year (Loyal *et al.* 1982). Dies off periodically (P. Hind pers. comm.).

Reproduction: Spores in sporocarps. Plants rarely fertile. Vegetative phase last for nearly 2 months, sporocarp formed before recession of water, sporocarp-bearing plant buried in dry cracking soil or through agricultural practices, life-span of sporophyte 5–6 months, population breeds freely for as many generations as is permitted by inundation (Loyal *et al.* 1982).

Dispersal, establishment & growth: Diaspore: sporocarps, rare. Plants usually multiplying by fragmentation. During the spring or in shaded situations the upper parts of the plant are green, whilst in summer and autumn and when exposed to full sunlight they usually become dark red. Plants can double leaf area in 7 days, dense growth usually indicating high nutrient levels (Sainty & Jacobs 1981). [Grows readily in aquaria particularly with a little fertilizer (Jones & Clemesha 1981).] Plants on periphery of population dispersed by wind currents and action of water birds (Loyal *et al.* 1982).

Fire response:

Interaction with other organisms: In Vietnam rice yields have been increased by cultivating *Azolla* in paddy fields. The blue-green alga *Anabaena azollae* in the leaves, fixes nitrogen from the air, which is released as the *Azolla* decays (Sainty & Jacobs 1981). Blocks pump inlets of dams and deters stock from watering (Auld & Medd 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC ST NWS SWS NWP SWP; Qld, Vic., N.T., S.A., trop. Asia.

Distribution Sydney area: Mainly coastal, not common.

Select locations: Richmond, Hoxton Park, Albion Park, Bathurst (P. Hind pers. comm.).

Habitat

Habitat: Mostly found covering the surface of still or slowly moving water.

Altitude: 0–700 m

Annual rainfall: 800–900 mm

Typical local abundance: Frequent.

Vegetation: Open-water.

Substrate: Water table permanently high — mostly found covering the surface of still or slowly moving fresh water.

Exposure: Not in shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).

A. pinnata less common in NSW than *A. filiculoides* (Sainty & Jacobs 1981).

Blechnum ambiguum**BLECHNACEAE**

Lance Water Fern

Life history**Growth form:** Terrestrial fern with short to medium creeping rhizome.**Vegetative spread:** Limited spread.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing period May– November, peak May. Most blechnums would probably peak late summer–early autumn with whole frond maturing at same time (E. Brown pers. comm.).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Difficult to keep growing (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC CT; Qld.**Distribution Sydney area:** Coast, Blue Mountains.**Select locations:** Woy Woy, Narrabeen, Royal NP, Minnamurra Falls, Glen Davis, Blackheath, Bundanoon.**Habitat****Habitat:** Common on wet rocks, usually on rock ledges below caves, near waterfalls or wet cliff-faces.**Altitude:** 0–1100 m**Annual rainfall:** 1000–1400 mm**Typical local abundance:****Vegetation:** Usually found in open-forest.**Substrate:** Sandstone. Infertile soil. Moisture supply continuous, water table permanently high.**Exposure:****Conservation****Conservation:** Conservation status unknown.**Blechnum camfieldii****BLECHNACEAE****Life history****Growth form:** Terrestrial fern with short-creeping rhizome, trunk often forming on older plants. (Can be confused with *Blechnum wattsii*, P. Hind pers. comm.).**Vegetative spread:** In swampy situations it reproduces by long stolons, but these are quite short in dry situations.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing period peak June, otherwise sporadic.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very easily grown and will tolerate a bit of sun and dryness (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC; Qld.**Distribution Sydney area:** Low-lying areas near the coast.**Select locations:** Colo River below Boorai Ridge, Gosford, Watagan Mtns, Somersby Falls, Gosford, Erina (P. Hind pers. comm.). Bayview, Kurnell, Oatley, Royal NP, Bulli, Milton.**Habitat****Habitat:** Low-lying saline swampy sites near the sea or along the margins of saltwater rivers, lakes and swamp.**Altitude:** 0–100 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** *Melaleuca quinquenervia* swamp, also near rainforest.**Substrate:** Swampy ground, brackish or fresh water. Common in but not restricted to saline situations (P. Hind pers. comm.).**Exposure:****Conservation****Conservation:** Regionally rare in Illawarra region (Mills 1988).

Probably also rare in other regions.

Blechnum cartilagineum

BLECHNACEAE

Gristle Fern

Life history**Growth form:** Erect, tufted terrestrial fern to 1 m high with short-creeping rhizome.**Vegetative spread:** Limited, forming groves.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing period peak April, August.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown, hardy in a dry situation (Jones & Clemesha 1981).]**Fire response:** Vigorous regrowth from rhizome after high intensity fire, fertile fronds after fire in less than 5 mths at Killarney Hts (L.McD.).**Interaction with other organisms:** Host to Leaf Nematodes (*Aphelenchoides* spp.) (Jones & Elliot 1986).**Status/origin:** Native.**Distribution****Botanical subregions:** NC CC SC CT ST CWS; Qld, Vic., Tas., Malaysia.**Distribution Sydney area:** Widespread, Coast and Blue Mountains.**Select locations:** Olney, Kurrajong, Hornsby, Killarney Heights (L.McD.), Manly, Wollongong, Kiama, Mt Wilson, Springwood, Bundanoon.**Habitat****Habitat:** On hillsides often amongst rocks, or stream banks.**Altitude:** 0–1000 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Frequent.**Vegetation:** Moist open-forest (e.g. with *Eucalyptus saligna*, *Angophora floribunda*) and rainforest.**Substrate:** Sandstone, basalt; sandy alluvium, sandy loam to red loam. Fertile soil. No salinity.**Exposure:** In sheltered, mid-shade situations.**Conservation****Conservation:** Common and adequately conserved.**Blechnum chambersii**

BLECHNACEAE

Life history**Growth form:** Terrestrial fern with short creeping to erect rhizome.**Vegetative spread:** Probably limited, very slow growing.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores late summer–early autumn in N.Z. (E. Brown pers. comm.). Spore size 27–35 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in a cool moist situation in Victoria but apparently difficult further north (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC ST; Vic., Tas., S.A., N.Z., Fiji.**Distribution Sydney area:** Localized.**Select locations:** Mt Tomah (P. Hind pers. comm.), Minnamurra Falls.**Habitat****Habitat:** Near creeks in shady areas where moisture is plentiful, in caves near waterfall.

Cool, shaded, moist gullies and rock walls (P. Hind pers. comm.).

Altitude: 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Rare.**Vegetation:** Rainforest.**Substrate:** Fertile soil. Commonly associated with flowing water (in Tasmania) (Jarman *et al.* 1986).**Exposure:** Shade-loving, rarely present in direct sunlight (Jarman *et al.* 1986).**Conservation****Conservation:** Rare in the Sydney area and regionally rare in Illawarra region (Mills 1988). Conservation status unknown.

Blechnum gregsonii

BLECHNACEAE

Broad Water Fern

Life history

Growth form: Terrestrial or lithophytic fern with short-creeping rhizome.

Vegetative spread: Probably limited.

Longevity: Probably indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing period April–May.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Difficult to keep growing (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC CT.

Distribution Sydney area: Blue Mountains and Minnamurra.

Select locations: Mt Wilson, Mt Victoria (P. Hind), Blackheath, Lawson (P. Hind), Minnamurra Falls.

Habitat

Habitat: Wet sandstone cliff faces.

Altitude: 600–1000 m **Annual rainfall:** above 1200 mm

Typical local abundance: Frequent, where found (P. Hind pers. comm.).

Vegetation: Rainforest.

Substrate: Pendent clumps found in damp places on rock ledges, under caves or near waterfalls. Walls of cave at Mt Victoria (P. Hind pers. comm.), often with *Blechnum ambiguum*. Infertile soil. Continuous moisture supply, fresh. Found where there is running water rather than on banks of creeks (P. Hind pers. comm.).

Exposure: Sheltered.

Conservation

Conservation: Rare, nationally coded 2 RC- (Briggs & Leigh 1988), only 3 Herbarium records for area, though known areas probably within National Parks.

Blechnum indicum

BLECHNACEAE

Swamp Water Fern

Life history

Growth form: Terrestrial fern with erect rhizome.

Vegetative spread:

Longevity:

Reproduction: Spores produced in sori on lower surface of frond.

Sporing period range January–August, peak February–April.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism.

Fire response:

Interaction with other organisms: Rhizomes roasted and eaten by Aborigines (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC; Qld, N.T., Malesia, Polynesia, Cent. Amer.

Distribution Sydney area: Coastal areas north from Jervis Bay.

Select locations: Cooranbong (P. Hind pers. comm.). Narrabeen (in Deep Creek. L.McD.), Ramsgate (1899), Kurnell, Cronulla, Berry, Jervis Bay, Bundanoon (1897).

Habitat

Habitat: Edge of brackish swamps or lakes.

Altitude: 0–500 m **Annual rainfall:** above 1200 mm

Typical local abundance: Frequent.

Vegetation: Swamp forest. Found with *Melaleuca quinquenervia*, *Casuarina glauca*, *Phragmites*, *Eucalyptus robusta*.

Substrate: Sandy loam, infertile. Water table permanently high, brackish or fresh. Will tolerate saline conditions (P. Hind pers. comm.).

Exposure: Very easily grown exposed to some sun. [Resents complete shade (Jones & Clemesha 1981).]

Conservation

Conservation: Conservation status unknown.

Blechnum minus**BLECHNACEAE**

Soft Water Fern

Life history**Growth form:** Terrestrial fern with short creeping rhizome.**Vegetative spread:** Individuals multiply very freely from offsets and build up into a large dense clump. Often forming masses (P. Hind pers. comm.).**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing period peak March–April. Spore size 33–45 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very easily grown and hardy in most situations, will tolerate full sun (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST SWS; Qld, Vic., Tas., S.A., N.Z.**Distribution Sydney area:** Blue Mountains, Moss Vale. Mostly at high altitudes, but may come down to lower Blue Mountains (Peter Hind pers. comm.).**Select locations:** Ilford, Spring Creek (Bathurst), Mt Victoria, Hazelbrook, Macquarie Pass, Kangaloon, Long Swamp (Kodala 1992), Minnamurra.**Habitat****Habitat:** Variety of moist habitats, narrow mountain gorges edge of waterfalls, or foot of falls, or swampy creeks. Upland mire (Kodala 1992).**Altitude:** 0–1000 m **Annual rainfall:** above 900 mm**Typical local abundance:** Frequent.**Vegetation:** Moist open-forest and rainforest. Banks of mountain streams with *Sphagnum*.**Substrate:** Amongst rocks, gravelly clay, sandstones. Fertile soils. Water table permanently high. No salinity. In damp areas liable to flood (P. Hind pers. comm.). Commonly associated with flowing water (in Tasmania) (Jarman *et al.* 1986).**Exposure:** Sheltered; light shade. Can tolerate more open sites than *B. wattsi* (Duncan & Isaac 1986). Will tolerate full sun (Jones & Clemesha 1981).**Conservation****Conservation:** Conservation status unknown.

Blechnum nudum

BLECHNACEAE

Fishbone Fern

Life history

Growth form: Terrestrial fern with short-creeping or erect rhizome sometimes forming a sturdy trunk.

Vegetative spread: Short-creeping rhizome forms dense colonies and excludes other ferns.

Longevity: Infinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing sporadic — March, August.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Recruitment mainly after fire (D. Keith pers. comm.). [Transplants easily and is very easily grown in moist, sheltered situations (Jones & Clemesha 1981).]

Fire response: New fronds often sprout from short burnt trunks (Duncan & Isaac 1986, D. Keith pers. comm.).

Interaction with other organisms: Host to Leaf Nematodes (*Aphelenchoides* spp.) (Jones & Elliot 1986).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Qld, Vic., Tas., S.A.

Distribution Sydney area: Coast (Calga–Cataract), Tablelands. Not found on the Cumberland Plain because creeks are ephemeral (P. Hind pers. comm.).

Select locations: Calga, Otford, Ilford, Wheeney Creek, Mt Wilson, Blackheath, Wentworth Falls, Mt Werong, Newnes Plateau, Mt Tomah (P. Hind), Yerrinbool.

Habitat

Habitat: Creek banks.

Altitude: 0–1200 m

Annual rainfall: above 1200 mm

Typical local abundance: Dominant–frequent.

Vegetation: Rainforest and open-forest or edges of forest and in heathland. Bottom of wet sclerophyll valleys, at base of cliffs (P. Hind pers. comm.).

Substrate: Sandstone, shale, granite, basalt — colluvial or alluvial soils. Fertile soils. Water supply continuous, fresh. More drought tolerant than *Todea barbara* (P. Hind pers. comm.).

Exposure: Requires light (P. Hind pers. comm.).

Conservation

Conservation: A widespread species that is probably adequately conserved.

Blechnum patersonii

BLECHNACEAE

Strap Fern

Life history

Growth form: Terrestrial fern with erect rhizome.

Vegetative spread: Clump forming.

Longevity: Probably indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores at any time, peak March–April, August–September.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Probably no dormancy mechanism. [Very easily grown in protected situations (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST CWS; Qld, Vic., Tas., SW Pac., Malesia.

Distribution Sydney area: Coast & Blue Mountains — widespread.

Select locations: Watagan Mtns, Bilpin, Bola Creek (P. Hind), Bulli, Macquarie Pass, Nowra, Mt Coricudgy, Mt Wilson, Blackheath, Fitzroy Falls, Bundanoon.

Habitat

Habitat: Below waterfalls and rock faces, earth bank on creeks and in moist forests (P. Hind pers. comm.).

Altitude: 0–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Rainforest and moist gullies.

Substrate: Sloping banks near creeks or in rocky crevices on sandstone, shale, basalt, granite. Water supply continuous, fresh. Not normally in flowing water (P. Hind pers. comm.).

Exposure: Sheltered; deep shade.

Conservation

Conservation: Probably adequately conserved.

Blechnum penna-marina

BLECHNACEAE

Alpine Water Fern

Life history**Growth form:** Terrestrial fern with wiry, branched, mostly long-creeping rhizome.**Vegetative spread:** Grows as low matted ground cover spreading by rhizome.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing peak probably November–December. Spore size 23–29 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Fertile fronds produced only in cool climates. [Grows during warmer months & dormant during winter (Jones & Clemesha 1981.) After winter dormancy the young bronze-pink fronds are conspicuous.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NT CT ST; Vic., Tas., N.Z., S America.**Distribution Sydney area:** Cooler mountain regions, rare.**Select locations:** Jenolan Caves, Lowther Creek, Oberon, Kanangra Tops (P. Hind).**Habitat****Habitat:** Creek banks.**Altitude:** c. 1000 m**Annual rainfall:** c. 1000 mm**Typical local abundance:** Frequent.**Vegetation:** In *Sphagnum* bogs and amongst rocks (P. Hind pers. comm.).**Substrate:** Granite, infertile soil. Moisture supply continuous, fresh. Not on sandstone, possibly on limestone (P. Hind pers. comm.).**Exposure:** Will tolerate full sun and low light level (P. Hind pers. comm.).**Conservation****Conservation:** Rare (only 3 Herbarium collections). Conservation status unknown.**Blechnum wattsii**

BLECHNACEAE

Hard Water Fern

Life history**Growth form:** Terrestrial fern with medium to long-creeping rhizome, sometimes mat-forming (P. Hind pers. comm.), (can be confused with *B. ambiguum* when fronds are sterile.).**Vegetative spread:** Forms extensive colonies by creeping rhizomes.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing period March, August. Often spores prolifically (Duncan & Isaac 1986).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very easily grown in semi-protected positions (Jones & Clemesha 1981.)]**Fire response:** Resprouts, produces flush of new fronds after fire (P. Hind pers. comm.).**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST; Qld, Vic., Tas., S.A.**Distribution Sydney area:** Upper Blue Mountains, Barren Grounds.**Select locations:** Mt Wilson, Mt Victoria, Blackheath, Lawson, Hazelbrook, Barren Grounds.**Habitat****Habitat:** Usually on the banks of creeks.**Altitude:** 500–1000 m**Annual rainfall:** 1200–1400 mm**Typical local abundance:** Frequent.**Vegetation:** In rainforest and less commonly along creeks in open-forests.**Substrate:** Soil very fertile–fertile. Basalt, sandstone. Moisture supply continuous, fresh.**Exposure:** Sheltered; mid shade.**Conservation****Conservation:** Conservation status unknown.

Doodia aspera**BLECHNACEAE**

Rasp Fern

Life history**Growth form:** Terrestrial fern with short creeping rhizome and underground runners (stolons).**Vegetative spread:** Spreads vegetatively by stolons, perhaps 5–10 cm/year to form large colonies, 5–10 m across.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores at any time, peak May, July (coastal), August (CT). Spore size 18–29 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Dispersal: no special morphology (Westoby *et al.* 1990). [Very easily grown in a variety of situations from shade to sun, hardy and tolerant of root competition (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS; Qld, Vic.**Distribution Sydney area:** Coast & Blue Mountains. Widespread particularly on Blue Mountains (P. Hind pers. comm.).**Select locations:** Ourimbah, Gosford, Wisemans Ferry, Pennant Hills, Otford, Razorback, Minnamurra Falls, Shoalhaven, Mt Wilson, Capertee, Mittagong, Bundanoon.**Habitat****Habitat:** Forested stream banks and among rocks in drier situations.**Altitude:** 0–900 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Tall eucalypt open-forest and rainforest margins, floodplain tall open-forest e.g. *Eucalyptus saligna*, *E. deanei*, *E. elata*, *E. tereticornis* (Scholer 1974). Also grows in dry eucalypt forest (P. Hind pers. comm.).**Substrate:** Sandy, and gravelly soils or richer loams; sandstone, basalt, volcanic necks, granite. Soil fertile–infertile. Water table mostly high, fresh. Not as water-dependent as many other ferns, will tolerate drought if not prolonged (P. Hind pers. comm.). In rock crevices and at the base of rocks, associated with creek lines.**Exposure:** Sheltered; mid shade but will tolerate full sun (P. Hind pers. comm.).**Conservation****Conservation:** Widespread and adequately conserved.**Doodia caudata var. caudata****BLECHNACEAE****Life history****Growth form:** Terrestrial fern with short creeping rhizome.**Vegetative spread:** Limited vegetative spread.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing February–September, peak March–April.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in sheltered position (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST; Qld, Vic., Tas., N.T., S.A., N.I., N.Z., N.Cal.**Distribution Sydney area:** Coast and Upper Blue Mountains.**Select locations:** Somersby, Berowra (P. Hind), Ku-ring-gai Chase NP, Kenthurst, Kogarah, Maldon, Razorback, Mt Kembla, Whispering Gallery, Minnamurra Falls, Wentworth Falls, Jenolan Caves, Wombeyan Caves.**Habitat****Habitat:** Various, moist creek banks to open rocky sites. Rock crevices in sheltered gullies (P. Hind pers. comm.).**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent–occasional–rare.**Vegetation:** Rainforest or tall open-forest.**Substrate:** Sandy soil, alluvial soil, sandstone, basalt, fertile–infertile. On vertical rock faces and also on benches; moisture supply continuous, fresh. (P. Hind pers. comm.).**Exposure:** Sheltered, mid shade.**Conservation****Conservation:** Conservation status unknown.

Doodia caudata var. laminosa

BLECHNACEAE

Life history

Growth form: Terrestrial fern with short creeping rhizome.

Vegetative spread: Limited vegetative spread.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond, in April.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [In cultivation easily grown but very slow with little inclination to form stolons (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms: Cannot stand competition (P. Hind pers. comm.).

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Rare, mainly Gosford-Hawkesbury area, also Minnamurra Falls.

Select locations: Killcare, Wondabyne, Upper Colo (P. Hind), Wisemans Ferry, Ku-ring-gai Chase NP, Kurrajong Hts, Wheeney Creek, Minnamurra Falls.

Habitat

Habitat: Protected sites, wet rock crevices.

Altitude: 0–500 m **Annual rainfall:** above 1200 mm

Typical local abundance: Locally common (P. Hind pers. comm.).

Vegetation: Rainforest & open-forest.

Substrate: Sandstone, rock crevices. Soil infertile. Water table mostly high, fresh. Well drained, vertical dwelling species on rock face and sometimes earth banks (P. Hind pers. comm.).

Exposure: Sheltered (P. Hind pers. comm.). Mid-light shade.

Conservation

Conservation: Rare, Minnamurra Falls southern limit (P. Hind pers. comm.).

Doodia media subsp. media

BLECHNACEAE

Life history

Growth form: Terrestrial fern with short creeping rhizome.

Vegetative spread: Spread rapidly by the production of runners (Duncan & Isaac 1986).

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very easily grown in a variety of situations from shade to sun, hardy and tolerant of root competition (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms: Cannot stand competition (P. Hind pers. comm.).

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT ST NWS; Qld, Vic., Tas.

Distribution Sydney area:

Select locations: Goodmans Ford (P. Hind pers. comm.). Herbarium records not available.

Habitat

Habitat: In gullies, in shady or exposed places, often amongst rocks.

Altitude: **Annual rainfall:** 800 mm

Typical local abundance:

Vegetation:

Substrate: On slates, mainly metamorphics, generally not on sandstone; found in wet places but tolerates periodic dryness; rocky sites, edge of creeks (P. Hind pers. comm.).

Exposure: Shady situations (P. Hind pers. comm.).

Conservation

Conservation: Conservation status unknown.

Cyathea australis**CYATHEACEAE**

Rough Treefern

Life history**Growth form:** Terrestrial arborescent fern with erect trunk to 20 m high and up to 40 cm diam.**Vegetative spread:** No vegetative spread.**Longevity:****Reproduction:** Spores produced in sori on lower surface of frond; peak February–May; Oct–Dec.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Spores retain viability 10–15 years (Jones 1987). [Very easily grown, easily raised from spores (Jones & Clemesha 1981).]**Fire response:** Resprouts from apex, old plants may have survived many bushfires.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS; Qld, Vic., Tas.**Distribution Sydney area:** Coast & Blue Mountains, widespread.**Select locations:** Gosford, Narrabeen, Otford, Bulli, Gerrington, Nowra, Kurrajong, Mt Tomah, Mt Wilson, Blackheath, Bundanoon.**Habitat****Habitat:** In gullies or on hillsides in moist shady situations.**Altitude:** 0–1050 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Widespread in rainforest or open-forest.**Substrate:** Sandstone, basalt, quartzite. Soil fertile. Moisture supply continuous.**Exposure:** Sheltered situations; deep–light shade.**Conservation****Conservation:** Vulnerable in Western Sydney (Benson & McDougall 1991).**Cyathea cooperi** ***CYATHEACEAE**

Straw Treefern

Life history**Growth form:** Terrestrial, arborescent fern with erect trunk to 12 m high and up to 15 cm diameter.**Vegetative spread:** No vegetative spread.**Longevity:****Reproduction:** Spores produced in sori on lower surface of frond. Few records.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind over long distances. Probably no dormancy mechanism. Fast growing. Reported as potential major weed in Hawaii where its rapid growth 0.3 m per year and high densities (1 plant per 6.4 m² in study plots) enable it to shade out understorey species (Medeiros *et al.* 1992). [Very easily grown and very hardy, heavy frosts may kill the fronds but plants quickly recover (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Not regarded as native to Sydney region but appears to be naturalized in Sydney as a garden escape (P. Hind pers. comm.).**Botanical subregions:** NC CC SC; Qld, W.A.***Distribution Sydney area:** Coastal, north from Durras Mountain, Illawarra (uncommon), North Shore suburbs. Sydney specimens date from 1950s but there is a collection from Jervis Bay 1942 (Steamer Beach) and Minnamurra Falls 1953 where it is probably native.**Select locations:** Jervis Bay, Minnamurra Falls*, Northbridge*, Beecroft*, Terrey Hills*.**Habitat****Habitat:** In gullies.**Altitude:** 0–200 m**Annual rainfall:** above 1000 mm**Typical local abundance:****Vegetation:** Warm coastal rainforest.**Substrate:** Soil fertile. Moisture supply continuous, fresh. Water table mostly high. Colonizes sandstone cuttings in Sydney.**Exposure:** Sheltered; light–deep shade.**Conservation****Conservation:** Adequately conserved.

Cyathea leichhardtiana**CYATHEACEAE**

Prickly Treefern

Life history**Growth form:** Terrestrial arborescent fern with erect trunk to 7 m high and 5–15 cm diam.**Vegetative spread:** No vegetative spread.**Longevity:****Reproduction:** Spores produced in sori on lower surface of frond. Spores peak March, May, otherwise sporadic.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Very slow growing. [In cultivation requires a well protected position (Jones & Clemesha 1981).]**Fire response:** Killed by high intensity fire (Chesterfield, Taylor & Molnar 1990).**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT; Qld, Vic.**Distribution Sydney area:** Coast & Blue Mountains.**Select locations:** Calga, Ku-ring-gai Chase NP, Otford, Bellambi, Minnamurra, Bilpin, Mt Wilson, Blackheath.**Habitat****Habitat:** Mountain slopes or near creeks.**Altitude:** 0–1000 m **Annual rainfall:** 1200–1600 mm**Typical local abundance:** Frequent.**Vegetation:** Warm and cool *Nothofagus* rainforest.**Substrate:** Basalt, sandstone. Soil fertile. No salinity.**Exposure:** Sheltered situations; mid shade.**Conservation****Conservation:** Uncommon, conservation status unknown.**Arthropteris beckleri****DAVALLIACEAE**

Small Jointed Fern

Life history**Growth form:** Epiphytic or climbing fern**Vegetative spread:** Rhizome long-creeping, forming mats.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very difficult to establish in cultivation but easy once established (Jones & Clemesha 1981).]**Fire response:** Probably killed.**Interaction with other organisms:** Epiphytic.**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC CT NWS; Qld.**Distribution Sydney area:** Coastal Ranges, north from the Cambewarra Range.**Select locations:** Gosford, Helensburgh, Mt Keira, Minnamurra Falls, Belmore Falls, Carrington Falls.**Habitat****Habitat:** Rainforest.**Altitude:** 0–600 m **Annual rainfall:** above 1200 mm**Typical local abundance:** Occasional.**Vegetation:** Rainforest.**Substrate:** On rocks or trees, sandstone boulders. Soil fertile. Moisture supply intermittent. No salinity.**Exposure:** Sheltered, mid shade.**Conservation****Conservation:** Conservation status unknown.

Arthropteris tenella**DAVALLIACEAE**

Jointed Fern

Life history**Growth form:** Epiphytic or climbing fern.**Vegetative spread:** Rhizome long-creeping.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores peak April and November, otherwise sporadically at any time. Spore size 41–59 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very difficult to establish in cultivation but easy to grow once established (Jones & Clemesha 1981).]**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT NWS; LHI, Qld, N.I., N.Z.**Distribution Sydney area:** Coastal, less commonly Blue Mountains.**Select locations:** Mt Warrawolong, Gosford, Royal NP, Mt Keira, Gerringong, Kangaroo Valley, Blackheath, Oberon, Robertson.**Habitat****Habitat:** Epiphytic or lithophytic, in gullies.**Altitude:** 0–1000 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Rainforest.**Substrate:** On rocks or trees, mainly basalt, occasionally sandstone. Fertile soils.

Moisture supply intermittent.

Exposure: Sheltered situations.**Conservation****Conservation:** Conservation status unknown.**Davallia pyxidata****DAVALLIACEAE**

Hare's Foot Fern

Life history**Growth form:** Epiphytic or lithophytic fern with long-creeping rhizome; aerial rhizomes act as litter-collecting device (Jones 1987).**Vegetative spread:** Forms clumps.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores at any time, too few records.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Dispersal: no special morphology (Westoby *et al.* 1990).

[Very easily grown (Jones & Clemesha 1981).] Sheds fronds during drought.

Fire response: Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT NWS CWS; Qld, Vic., Tas.**Distribution Sydney area:** Mainly coastal.**Select locations:** Patonga, Pittwater, Oatley, Cambewarra, Nowra, Barren Grounds.**Habitat****Habitat:** Epiphytic and in rock crevices.**Altitude:** 0–600 m**Annual rainfall:** 1000–1400 mm**Typical local abundance:** Occasional.**Vegetation:** Rainforest and eucalypt forest.**Substrate:** Sandstone & basalt. Epiphytic on trees in rainforests or climbing over rocks in eucalypt forests. Soil fertile–infertile. Moisture supply intermittent, fresh.**Exposure:** Sheltered situations.**Conservation****Conservation:** Conservation status unknown.

Nephrolepis cordifolia ***DAVALLIACEAE**

Fishbone Fern

Life history

Growth form: Terrestrial fern with abundant stolons; upper surface of frond secretes a calcareous substance, frequently bears potato-like tubers on rhizomes (Tryon 1982).

Vegetative spread: Spreads by stolons to form dense mats. Can reproduce from tubers (Jones 1987).

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spore size 17–22 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind but mainly dispersed vegetatively by humans in garden waste etc. Often cultivated; escaped and established in the Sydney area. Tubers formed on roots.

Fire response: Probably resprouts.

Interaction with other organisms: Infusions and decoctions used to cure chest complaints; tubers eaten after roasting, in Nepal (Jones 1987).

Distribution

Status/origin: Naturalized in Sydney region, though native north of the Clarence River.

Botanical subregions: NC CC*; Qld, N.T., pantrop.

Distribution Sydney area: Naturalised in Sydney suburban area, particularly North Shore.

Select locations: Lindfield, Willoughby, Mosman. (Limited data.)

Habitat

Habitat: Gardens and urban bushland.

Altitude: 0–200 m

Annual rainfall: above 1000 mm

Typical local abundance: Frequent.

Vegetation: Disturbed sites, bushland margins.

Substrate: Amongst rocks. Soil fertile–infertile. Moisture supply intermittent, fresh.

Exposure: Deep shade.

Conservation

Conservation: Localized invasion of bushland, generally from adjacent garden edges, minor problem.

Rumohra adiantiformis**DAVALLIACEAE****Life history**

Growth form: Epiphytic or lithophytic fern with long-creeping rhizome.

Vegetative spread: Long-creeping rhizome forms mats or clumps.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing peak May–June, October, range May–December. Spore size 21–30 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Resents disturbance, but once established is easy to grow (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC NT CT ST; Qld, Vic., Tas., N.Z., S Africa, S & C Amer.

Distribution Sydney area: Mainly Blue Mountains.

Select locations: Mt Wilson, Mt Tomah, Blackheath, Mt Victoria, Hilltop, Minnamurra Falls.

Habitat

Habitat: Epiphytic on cliffs, rocks or trees.

Altitude: 0–1100 m

Annual rainfall: above 1400 mm

Typical local abundance: Frequent.

Vegetation: Rainforest margins.

Substrate: Epiphytic on rocks (sandstone) and trees, particularly treeferns. Soil fertile. Moisture supply continuous, fresh.

Exposure:

Conservation

Conservation: Relatively common in the Blue Mountains but regionally rare in Illawarra region (Mills 1988).

Dennstaedtia davallioides**DENNSTAEDTIACEAE**

Lacy Ground Fern

Life history**Growth form:** Terrestrial, long-creeping, stout rhizome.**Vegetative spread:** Creeping rhizome forms colonies.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in a cool, protected situation.]**Fire response:****Interaction with other organisms:** The plants may be severely attacked by green caterpillars (Jones & Clemesha 1981).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC CT; Qld, Vic., N.I.**Distribution Sydney area:** Upper Blue Mountains and Illawarra.**Select locations:** Waterfall, Mt Tomah, Mt Wilson, Jenolan Caves.**Habitat****Habitat:** Cool shaded areas, particularly alluvial flats along streams. Edge of rainforest.**Altitude:** 0–1000 m**Annual rainfall:** above 1400 mm**Typical local abundance:** Frequent.**Vegetation:** Rainforest margins or moist sites in tall open-forest e.g. with *Pteridium esculentum* or *Pellaea falcata*. Ground stratum.**Substrate:** Fertile alluvial soils. Basalt. Water table mostly low, moisture supply intermittent, fresh.**Exposure:** Light shade.**Conservation****Conservation:** Conservation status unknown.**Histiopteris incisa****DENNSTAEDTIACEAE**

Bat's Wing Fern

Life history**Growth form:** Terrestrial fern with long-creeping rhizome.**Vegetative spread:** Long-creeping rhizome often forms extensive colonies many metres across.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores mainly January–May.

Spore size 21–29 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Growth seasonal, fronds produced in a flush of growth (e.g. in late winter, summer) (E. Brown pers. comm.). [Easily transplanted.]**Fire response:** Resprouts in swampy sites.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST; Qld, Vic., Tas., N.T., S.A., trop. and S Hemi.**Distribution Sydney area:** Coast and Blue Mountains.**Select locations:** Boudi, Peats Crater (L.McD.), Narrabeen, Balmain, Kurnell, Waterfall, Mt Tambo, Kurrajong, Wolgan Gap, Linden, Bowral.**Habitat****Habitat:** Moist sheltered sites, gullies, sandstone cliff lines, lake edges.**Altitude:** 0–900 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Occasional–frequent.**Vegetation:** Rainforest and moist eucalypt forest or scrub near water.**Substrate:** Moist sandy soil, low nutrient. Water table permanently high, moisture supply continuous.**Exposure:** Sheltered, mid–light shade.**Conservation****Conservation:** Probably adequately conserved.

Hypolepis glandulifera**DENNSTAEDTIACEAE****Life history**

Growth form: Terrestrial fern with thick long-creeping rhizome and stout stems.

Vegetative spread: Creeping rhizome usually forming large colonies. Often forms tall thickets in area opened up to light. Can spread 1–2 m per year.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Quick growing, especially during wet periods in summer. [Easily transplanted and very easily grown in a damp position.]

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST CWS; Qld, Vic., N.G., N.Cal, Malesia, India.

Distribution Sydney area: Coast south of Port Hacking and Tablelands.

Select locations: Garie, Macquarie Pass, Minnamurra Falls, NW of Windsor, Springwood, Jenolan Caves, Robertson.

Habitat

Habitat: Open sites near rainforest, usually along creek banks.

Altitude: 0–900 m **Annual rainfall:** above 900 mm

Typical local abundance: Frequent.

Vegetation: In or near rainforest.

Substrate: Moderate nutrient soils, sometimes sandy. No salinity, water table mostly high.

Exposure: Light shade.

Conservation

Conservation: Conservation status unknown.

Hypolepis muelleri**DENNSTAEDTIACEAE**

Harsh Ground Fern

Life history

Growth form: Terrestrial fern with long-creeping rhizome.

Vegetative spread: Creeping rhizome often forming open colonies spreading to 0.5 m per year.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores dispersed by wind. Probably no dormancy mechanism. Sporing mainly November–July, peak February.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Summer growing. [Very easily grown in a moist position even tolerating full sun (Jones & Clemesha 1981).]

Fire response: Resprouts from rhizome.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST CWS; Qld, Vic., Tas.

Distribution Sydney area: Coast & occasionally Tablelands.

Select locations: Gosford, Avalon, Mascot, Upper Cordeaux Dam, Culoul Range, Cattai, Wedderburn, Rylstone, Bundanoon.

Habitat

Habitat: Along creeks and in swamps.

Altitude: 0–700 m **Annual rainfall:** above 1200 mm

Typical local abundance: Frequent.

Vegetation: Margin of rainforest or open-forest, floodplain tall open-forest e.g. *Eucalyptus tereticornis* or *Melaleuca*; sometimes a dominant feature of the ground flora.

Substrate: Sandy alluvial soils, medium nutrient; sandy soils, sandstone. Water table permanently high, ?brackish or fresh.

Exposure: Sheltered; light, no shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.

Hypolepis rugosula

DENNSTAEDTIACEAE

Life history

Growth form: Terrestrial fern with slender long-creeping rhizome.

Vegetative spread: Creeping rhizome forming extensive colonies.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing peak March, but few records.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in a damp position (Jones & Clemesha 1981.)]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CT CWS SWS; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Blue Mountains.

Select locations: Mt Wilson, Mt Tomah, Blackheath, Jenolan Caves, NE of Bathurst.

Habitat

Habitat: Mountain gullies near creeks or in swampy land.

Altitude: 800–1000 m

Annual rainfall: 1100–1400 mm

Typical local abundance:

Vegetation:

Substrate: Basalt, sandstone, trachyte. Soil fertile–infertile. Non-saline.

Exposure: Can tolerate relatively high light intensities and form dense cover in open situations (in Tasmania) (Jarman *et al.* 1986).

Conservation

Conservation: Conservation status unknown.

Pteridium esculentum**DENNSTAEDTIACEAE**

Bracken

Life history

Growth form: Terrestrial fern with stiff fronds to 1.5 m high, nectaries on young fronds; long-creeping much branched rhizome.

Vegetative spread: Vegetative spread mainly by rhizome. Produces an enormous reserve of underground rhizome apices, produced each time a frond is produced. These may grow or remain dormant (O'Brien 1963 in Thomson & Smith 1990).

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores February–July. Spore size 24–33 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Dispersal: no special morphology (Westoby *et al.* 1990). Only one (unverified) published record of sporeling establishment in forest environments in Australia (Tolhurst in Thomson & Smith 1990). Has spread by spores in the past and the potential to do so still exists (A.F. Dyer in Thomson & Smith 1990). Otherwise spreads vegetatively, particularly after fire. In absence of frosts grows continuously throughout year, with a few new fronds in winter but most in autumn and spring. There is always spring growth, but may be little or no summer or autumn growth; vigorous new growth after rain. Very drought resistant. Dormant rhizome buds may remain dormant for at least 10 years (O'Brien 1963). Frond longevity is normally about 12 months (Tolhurst in Thomson & Smith 1990). Fronds cut in summer will cause rhizomes to grow and produce another frond, until March (O'Brien 1963). Transplantation said to be difficult e.g. by Jones & Clemesha — not so, provided care is taken to use undamaged portion of rhizome (cracks in sclerotised rhizome surface allow entry of fungi etc) including shoot apex and leaf primordia as well as dormant buds if possible, with adequate length of older rhizome to provide storage reserves during establishment period. Transplant in spring or early autumn (J. Thomson pers. comm.).

Fire response: Leaves burnt but resprouts rapidly (within a month even in absence of rain). May be indicative of frequent fire and is able to survive annual burning (Bradstock 1981). May become dominant after a low intensity burn but show no significant spread after a high intensity fire. One year after spring burning individual frond size and total biomass increased, but after autumn burning frond size decreased and biomass was unaltered (Tolhurst 1990 in Thomson & Smith).

Interaction with other organisms: Simulated rainwater run-off from undamaged juvenile and mature fronds inhibited radicle elongation in *Medicago* and *Trifolium*. Run-off from juvenile but not mature fronds inhibited radicle extension in *Eucalyptus haemastoma* seedlings (Taylor & Thomson in Thomson & Smith 1990). Endemic Australian Drosophilidae: adult flies come to nectaries along with ants and spiders. *Drosophila notha*: larvae are gregarious tunnellers in stipe and rachis (J. Thomson pers. comm.). *Drosophila megagenys*: solitary larvae form galls at tips of pinnae and pinnules (Thomson, Jackson & Bock 1982). For herbivorous arthropod fauna in the Sydney area see Shuter & Westoby (1992). Ingestion of the green parts of this fern by animals (poultry also affected) causes haemorrhage and/or death, the rhizomes are apparently eaten without injury (Hurst 1942). Used in some coastal areas of Australia to stabilize areas after sand mining (Jones 1987). Nectaries on young fronds may encourage ants to set up colonies nearby, discouraging fern-herbivores e.g. slugs and snails (Page 1982).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS SWP; Qld, Tas., S.A., N.Z., Pac Is. See also Thomson, Willoughby & Shearer 1986.

Distribution Sydney area: Widespread, Coast and Blue Mountains.

Select locations: Gosford, Palm Beach, Oatley, Agnes Banks, Lake Illawarra, Cambewarra, Kandos, Blackheath, Glanmire, Penrose, Long Swamp (Kodala *et al.* 1992).

Habitat

Habitat: Open-forest, damp sandy flats, sandstone gullies, pasture land or at the edge of sand dunes. Bracken is most abundant in cleared agricultural land at high altitudes, in high rainfall areas, and where January maximum and July minimum temperatures are low; natural vegetation is dry sclerophyll woodland, and the soils are deep, well structured and initially of high fertility. In woodland communities, the correlation of bracken abundance are similar, but include association with mixed eucalypt forests, and with deep coarse-textured soil types showing good drainage (Thomson, Willoughby & Shearer 1986). Margin of upland mire (Kodala *et al.* 1992).

Altitude: 0–1200 m **Annual rainfall:** above 700 mm

Typical local abundance: Dominant-common.

Vegetation: Open eucalypt forest and woodland, pasture land, or floodplain in tall open-forest e.g. with *Eucalyptus deanei*, *E. tereticornis*, *Angophora floribunda*.

Pteridium esculentum (continued)

DENNSTAEDTIACEAE

Substrate: May occur on very fertile–very infertile soils, sandy loams or sands from sandstone, volcanics and alluvium. Rarely on clay soils. Water table permanently low, fresh. Generally well-drained sites. In drier areas may occur near water. Colonizes low pH (2.5–6.5) acid sulphate estuarine soils in the Wyong area (Payne 1992).

Exposure: Exposed–sheltered situations, light shade–no shade.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991) and adequately conserved elsewhere. May be considered a weed in agricultural situations.

Calochlaena dubia (*Culcita dubia*)

DICKSONIACEAE

Common Ground Fern

Life history

Growth form: Terrestrial fern with stout, creeping rhizome.

Vegetative spread: Spread by rhizome to form almost pure stands with fronds to 2 m tall.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores January–June.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Dispersal: no special morphology (Westoby *et al.* 1990). Recruitment mainly after fire (D. Keith pers. comm.). Spreads about 0.3 m per year. New frond growth in October, and after rain during growing period. [Easily cultivated. Will tolerate considerable exposure but does not seem to persist long after clearing (Jones & Clemesha 1981).]

Fire response: Leaves scorched & burnt. May shoot within a month of burning even without rain. No significant spread after high intensity fire but may become dominant after low intensity fire (at Mosman). Resprouts vigorously at ground level or below. May indicate frequent, low intensity fire regime.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST CWS; Qld, Vic., Tas.

Distribution Sydney area: Coast, Gosford–Nowra and Blue Mountains; widespread & common.

Select locations: Gosford, Pennant Hills, Chowder Head, Royal NP, Mt Kembla, Mt Wilson, Blackheath, Springwood, Bundanoon.

Habitat

Habitat: Eucalypt forests on poor soils in open places or sheltered gullies, often on sandstone gullies. Forested slopes, creek banks and roadsides.

Altitude: 0–900 m **Annual rainfall:** above 1200 m

Typical local abundance: Dominant–frequent.

Vegetation: Eucalypt tall open-forest or open-forest.

Substrate: Usually on poorer soils, sandstones, shales. Soil fertile–infertile. Water table mostly high, moisture supply continuous, fresh. Well drained. Colonizes low pH (2.5–6.5) acid sulphate estuarine soils in the Wyong area (Payne 1992).

Exposure: Sheltered; light shade–no shade.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991) and adequately conserved elsewhere.

Dicksonia antarctica**DICKSONIACEAE**

Soft Treefern

Life history**Growth form:** Treefern with thick trunk to 4.5 m high.**Vegetative spread:** No.**Longevity:****Reproduction:** Spores produced in sori on lower surface of frond. Sporing peak May, August.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Spores retain viability 10–15 years (Jones 1987). [Very hardy, grows very easily (Jones & Clemesha 1981).]**Fire response:** Resprouts.**Interaction with other organisms:** Both possums & parrots eat the young croziers and at times are very destructive (Jones & Clemesha 1981). Aborigines ate the pith from the centre of the trunk (Jones & Clemesha 1981).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC ST NT CT ST CWS; Qld, Vic., Tas., S.A.**Distribution Sydney area:** Illawarra, Blue Mountains.**Select locations:** Mt Kembla, Minnamurra, Mt Coricudgy, Mt Wilson, Mt Tomah, Jenolan Caves, Mt Werong, Bundanoon.**Habitat****Habitat:** Widespread in mountain gullies, usually along creeks.**Altitude:** 400–900 m**Annual rainfall:** 1400 mm**Typical local abundance:****Vegetation:** Cooler rainforest**Substrate:** Red clay loam derived from basalt. No salinity.**Exposure:** Sheltered.**Conservation****Conservation:** Conservation status unknown.**Arachniodes aristata****DRYOPTERIDACEAE****Life history****Growth form:** Terrestrial fern with creeping rhizome.**Vegetative spread:** Long-creeping rhizome forms colonies and occasionally dense masses to 2 m high.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spore size 25–42 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very slow to spread in cultivation (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC; Qld, Pac, Malesia, Asia.**Distribution Sydney area:** Chiefly in north coastal regions.**Select locations:** Newport (1906). Herbarium records not available.**Habitat****Habitat:** Rainforest especially near creeks, often on mountain slopes.**Altitude:****Annual rainfall:****Typical local abundance:****Vegetation:** Rainforest especially near creeks.**Substrate:****Exposure:** Sheltered.**Conservation****Conservation:** Conservation status unknown.

Cyrtomium falcatum * cv 'Rochfordii'

DRYOPTERIDACEAE

Holly Fern

Life history**Growth form:** Terrestrial fern with short rhizome.**Vegetative spread:** Creeping rhizome. Can reproduce from large pieces of old withered rhizome — dormant vegetative buds become active when rhizome is detached from plant (Jones 1987).**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond (inadequate material).

Spore size 29–39 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to Japan. Probably a garden escape.**Botanical subregions:** CC.**Distribution Sydney area:** Sydney Harbour and the coast.**Select locations:** Garigal NP (L.McD.), Curl Curl, Rose Bay, Coogee, Cape Solander, Cronulla.**Habitat****Habitat:** Crevices of cliffs and walls.**Altitude:** 0–200 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Rare.**Vegetation:****Substrate:** Sandstone cuttings and crevices close to the sea.**Exposure:****Conservation****Conservation:** Restricted exotic species.**Lastreopsis acuminata**

DRYOPTERIDACEAE

Shiny Shield Fern

Life history**Growth form:** Terrestrial fern with short-creeping, thick rhizome, fronds to 90 cm long.**Vegetative spread:** Probably limited.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing peak May and August (but few records).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT NWS CWS; Qld, Vic., Tas., S.A.**Distribution Sydney area:** Coast and Blue Mountains.**Select locations:** Watagan Mtns, Royal NP, Bulli Pass, Minnamurra Falls, Mt Coricudgy, Mt Wilson, Mt Tomah.**Habitat****Habitat:** Usually near creeks.**Altitude:** 0–800 m**Annual rainfall:** above 1400 mm**Typical local abundance:** Frequent.**Vegetation:** Rainforest and wet sclerophyll forest.**Substrate:** Basalt soils, very fertile. Water table mostly high, moisture supply continuous, fresh.**Exposure:** Deep shade.**Conservation****Conservation:** Conservation status unknown.

Lastreopsis decomposita**DRYOPTERIDACEAE**

Trim Shield Fern

Life history**Growth form:** Terrestrial fern with short-creeping rhizome.**Vegetative spread:** Sometimes covers large areas.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing peak May, (but few records).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Dispersal: no special morphology (Westoby *et al.* 1990). [Easily grown (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT CWS; Qld, Vic.**Distribution Sydney area:** Widespread, Coast and Lower Blue Mountains.**Select locations:** Culoul Range, Mountain Lagoon, Ourimbah, McCarrs Creek, Garie, Mt Kembla, Macquarie Pass, Nortons Basin, Leura.**Habitat****Habitat:** Rocky gullies and hillsides.**Altitude:** 0–800 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Sometimes covers large areas.**Vegetation:** Rainforest and wet sclerophyll forest.**Substrate:** Basalt, sandstone. Soil fertile. No salinity.**Exposure:** Sheltered situations.**Conservation****Conservation:** Conservation status unknown.**Lastreopsis hispida****DRYOPTERIDACEAE**

Bristly Shield Fern

Life history**Growth form:** Terrestrial fern with long-creeping rhizome, fronds to 15–60 cm long, sometimes to 90 cm.**Vegetative spread:** Long-creeping rhizome.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spore size 33–45 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown but very slow (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CT; Vic., Tas., N.Z.**Distribution Sydney area:** Blue Mountains, rare.**Select locations:** Waterfall Gully, Mt Wilson (1903), Happy Valley, Mt Wilson (1914), Blue Mountains (1903) (Tindale 1963) Herbarium records not available.**Habitat****Habitat:** Shady wet situations, often in gravelly soil or on mossy or rotting logs (Jones & Clemesha 1981).**Altitude:** 1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Rare.**Vegetation:** Rainforest.**Substrate:** Moisture supply continuous.**Exposure:** Deep shade.**Conservation****Conservation:** Conservation status unknown.

Lastreopsis microsora**DRYOPTERIDACEAE**

Creeping Shield Fern

Life history**Growth form:** Terrestrial fern.**Vegetative spread:** Long-creeping rhizome, often forming large clumps.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing March, May.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Dispersal: no special morphology (Westoby *et al.* 1990). [Very easily grown (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT; Qld, Vic., N.Z.**Distribution Sydney area:** Widespread, coast, Blue Mountains.**Select locations:** Gosford, Newport, Bulli Pass, Minnamurra Falls, Cambewarra, Fitzroy Falls, Mt Tomah, Mt Irvine, Mt Wilson, Blackheath, Wentworth Falls.**Habitat****Habitat:****Altitude:** 0–900 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Common.**Vegetation:** Rainforest and wet sclerophyll forest.**Substrate:** Coastal sandy alluvium, basalt soils, alluvium. Soil very fertile–fertile. No salinity.**Exposure:** Sheltered situations.**Conservation****Conservation:** Conservation status unknown.**Polystichum australiense****DRYOPTERIDACEAE****Life history****Growth form:** Terrestrial fern.**Vegetative spread:** Proliferous buds often present on the main rachis.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing peak Aug, range June–Nov.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very easily grown (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC CT CWS.**Distribution Sydney area:** Widespread. Coast & Blue Mountains.**Select locations:** Watagan Mtns, Otford, Minnamurra Falls, Mountain Lagoon, Erskine Creek, Mt Wilson, Blackheath, Capertee, Bundanoon.**Habitat****Habitat:** Gullies & hillsides, near creeks.**Altitude:** 0–1000 m**Annual rainfall:** above 900 mm**Typical local abundance:** Frequent.**Vegetation:** Open-forest and on rainforest margins.**Substrate:** Basalt, sandstone gully soils. No salinity.**Exposure:** Sheltered situations; mid shade.**Conservation****Conservation:** Conservation status unknown.

Polystichum formosum

DRYOPTERIDACEAE

Broad Shield Fern

Life history

Growth form: Terrestrial fern.

Vegetative spread: Probably limited.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing time ? (inadequate records).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC NT CT; Qld, Vic.

Distribution Sydney area: Only recorded from Fitzroy Falls and Sunny Corner.

Select locations: Fitzroy Falls, Sunny Corner.

Habitat

Habitat: Rocky gorges near waterfalls.

Altitude: 500–1000 m **Annual rainfall:** 1000–1400 mm

Typical local abundance: Rare.

Vegetation: Rainforest or eucalypt forest.

Substrate: Basalt, trachyte. Soil fertile. Water table mostly high, fresh.

Exposure:

Conservation

Conservation: Regionally rare in Illawarra region (Mills 1988) and elsewhere.

Polystichum proliferum

DRYOPTERIDACEAE

Mother Shield Fern

Life history

Growth form: Terrestrial fern with thick, ascending, scaly rhizome.

Vegetative spread: Plantlets formed from proliferous buds near ends of fronds take root and form large colonies (Jones & Clemesha 1981).

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond, mainly August–December.

Spore size 27–39 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Possibly dispersed locally by plantlets. [Very easily grown (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS; Vic., Tas.

Distribution Sydney area: Mainly Upper Blue Mountains.

Select locations: Mt Coricudgy, Mt Wilson, Mt Tomah, Mt Werong, Jenolan Caves, Wentworth Falls, Minnamurra Falls.

Habitat

Habitat: Cool mountain areas.

Altitude: 0–1200 m **Annual rainfall:** above 1200 mm

Typical local abundance: Frequent.

Vegetation: Rainforest, or moist eucalypt open-forest.

Substrate: Basalt loam, high nutrient on hillsides and in valleys.

Exposure:

Conservation

Conservation: Conservation status unknown.

Equisetum arvense*

EQUISETACEAE

Common Horsetail, Scouring Rush

Life history

Growth form: Perennial herb with erect annual stems, fertile and sterile, usually hard and covered with siliceous deposits; stems consist of nodes and internodes with branches radiating in whorls from each node, whorled leaves reduced to scales. Perennial pubescent rhizomes to several metres long.

Vegetative spread: Plant shoots from an extensive system of rhizomes which divide frequently. New plants grow from rhizome fragments and from tubers. Spreads quickly.

Longevity: Indefinite.

Reproduction: Spores formed in terminal cones on short-lived brownish shoots in spring. Spore size 39–59 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Spores have strap-like arms or elators which are hygroscopic and move with variations in humidity; movement of the elators entangles other spores so they are shed in groups (Jones 1987). Spores contain chlorophyll and germinate in light on soil surface (Jones 1987). Needs prolonged moist conditions to germinate and grow — usually spreads by vegetative reproduction.

Fire response:

Interaction with other organisms: Poisonous to stock; horses and sheep particularly susceptible and can die within a few hours of eating large amounts of the plant. Dried plant more poisonous — can be a contaminant of hay. High densities in agricultural land reduce crop yield by producing inhibitory substances that depress the growth of neighbouring plants (Smith & Trounce 1990).

Distribution

Status/origin: Exotic, native to S Africa. Introduced as a garden plant, occasionally cultivated as an ornamental plant or medicinal herb.

Botanical subregions: CC CWS; Eur., Asia, N Amer.

Distribution Sydney area: Sydney suburban area.

Select locations: Belrose.

Habitat

Habitat: Gardens or adjacent bushland.

Altitude: 0–200 m **Annual rainfall:** above 1200 mm

Typical local abundance: Frequent.

Vegetation: Eucalypt woodland adjacent to gardens.

Substrate: Free draining gravelly or sandy soils, porous soils with high water tables, and poorly drained depressions or swamps (Smith & Trounce (1990).

Exposure: Indifferent.

Conservation

Conservation: Exotic garden plant rarely reported as naturalized. Could become a persistent weed of cultivated land and invade disturbed native vegetation particularly on damp ground on river banks and lake margins. Difficult to eradicate. Declared noxious in parts of Sydney.

Dicranopteris linearis**GLEICHENIACEAE****Life history**

Growth form: Terrestrial fern with long-creeping rhizome.

Vegetative spread: Long-creeping rhizome often straggling and forming dense thickets.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing peak ? Aug. (limited data).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Damaged by disturbance but small plants establish easily; will not survive drying out of root system (Jones & Clemesha 1981).

Fire response:

Interaction with other organisms: Rhizomes recorded as edible; used externally in poultices or emollients to treat wounds, burns, bruises, and sprains; pliant stems widely used in Asia for ropes, baskets, hats, fish traps (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld, N.T., tropics.

Distribution Sydney area: North from Royal NP, widespread but now rare.

Select locations: Hawkesbury River (1895), Gordon West, Chatswood, Loftus.

Habitat

Habitat: Banks of streams in permanently damp situations, sometimes in sandstone road cuttings in Sydney area.

Altitude: 0–300 m

Annual rainfall: above 1200 mm

Typical local abundance: Rare.

Vegetation: In eucalypt forest.

Substrate: Sandstone crevices. Soil infertile. Moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Very rare, probably inadequately conserved.

Gleichenia dicarpa**GLEICHENIACEAE****Life history**

Growth form: Terrestrial fern with long-creeping rhizome.

Vegetative spread: Long-creeping rhizome forms large scrambling colonies.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores at any time except July; peak April, August–Sept (coast), April, October (mountains). Spore size 26–33 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores, dispersed by wind, probably no dormancy mechanism. Young plants establish on wet cliff lines, soaks etc. Recruitment mainly after fire (D. Keith pers. comm.). Easily grown from spores. [A hardy fern but difficult to transplant, will not tolerate the root system drying out (Jones & Clemesha 1981).]

Fire response: Resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Qld, Vic., Tas., N.Z., N.G., N.Cal, Philipp.

Distribution Sydney area: Common, widespread species; coast & Blue Mtns.

Select locations: Gosford, Ku-ring-gai Chase NP, Castlecrag, Kogarah, Appin, Cambewarra, Minnamurra, Blackheath, Woodford, Kanangra, Bundanoon.

Habitat

Habitat: In sunny damp sites around swamps & bases of cliffs.

Altitude: 20–1200 m

Annual rainfall: above 1000 mm

Typical local abundance: Frequent–occasional.

Vegetation: Rainforest margins and tall open-forest.

Substrate: Sandy or peaty soil — low nutrient, permanently running water; sandstone, quartzite.

Water table permanently high, moisture supply continuous, fresh.

Exposure: Sheltered situations; mid–light shade.

Conservation

Conservation: Probably adequately conserved.

Gleichenia microphylla**GLEICHENIACEAE****Life history**

Growth form: Terrestrial fern with long-creeping rhizome.

Vegetative spread: Long-creeping rhizome forming large scrambling colonies.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores at any time except May–June, peak Oct. Spore size 25–38 μm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Recruitment mainly after fire (D. Keith pers. comm.). [Hardy but difficult to transplant; easily grown from spores (Jones & Clemesha 1981).]

Fire response: Resprouts (D. Keith pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT; all states, N.Z., SE Asia.

Distribution Sydney area: Widespread species, coast & Blue Mtns.

Select locations: Gosford, Royal NP, Barrengarry, Lawson, Blackheath, Newnes Junction, Nepean Dam, Macquarie Pass.

Habitat

Habitat: In sunny damp sites around swamps at bases of cliffs. Stunted plants seen in rock crevices (Jones & Clemesha 1981).

Altitude: 10–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Open-forest.

Substrate: Sandy or peaty soils — low nutrient; sandstone. Water table permanently high, moisture supply continuous, fresh.

Exposure: Sheltered situations; mid shade.

Conservation

Conservation: Probably adequately conserved.

Gleichenia rupestris**GLEICHENIACEAE****Life history**

Growth form: Terrestrial fern with long-creeping rhizome.

Vegetative spread: Long-creeping rhizome forming scrambling colonies.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing period January–May, September–October, peak March.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Dispersal: no special morphology (Westoby *et al.* 1990). [A hardy fern but difficult to transplant, easily grown from spores (Jones & Clemesha 1981).]

Fire response: Resprouts (Bantry Bay 1991, L.McD.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST; Qld, ?Vic.

Distribution Sydney area: Coast & Upper Blue Mtns, common.

Select locations: Gosford, Hornsby, Bantry Bay, Royal NP, Bulli, Brogers Creek, Mt Wilson, Blackheath, Wentworth Falls, Bundanoon.

Habitat

Habitat: Crevices in cliffs.

Altitude: 0–1200 m

Annual rainfall: above 1200 mm

Typical local abundance: Common–frequent.

Vegetation: In open-forest or woodlands.

Substrate: Low to medium nutrient, on sandstone. Soil infertile or very infertile. Water table mostly high, moisture supply continuous–intermittent, fresh.

Exposure: Sheltered situations.

Conservation

Conservation: Probably adequately conserved.

Sticherus flabellatus**GLEICHENIACEAE**

Umbrella Fern

Life history**Growth form:** Terrestrial fern with long-creeping rhizome.**Vegetative spread:** Long-creeping rhizome forming large colonies.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores at any time except June & Sept (CC) Jan–March (CT), peak Aug (CC) Jan (CT). Spore size 14–18 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Resents disturbance but small plants adapt to cultivation, will not tolerate drying of the root system (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC CT ST; Qld, Vic., N.Z., N.Cal.**Distribution Sydney area:** Coast & Blue Mtns.**Select locations:** Mt White, Cheltenham, Royal NP, Bargo, Shoalhaven Gorge, Springwood, Blackheath, Glen Davis, Bundanoon.**Habitat****Habitat:** Moist gullies, damp soaks, along creeks, permanent moisture.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Eucalypt forests or edge of rainforest.**Substrate:** Sandy soils, infertile. Water table permanently high, moisture supply continuous, fresh.**Exposure:** Sheltered situations; mid–light shade.**Conservation****Conservation:** Probably adequately conserved.**Sticherus lobatus****GLEICHENIACEAE**

Spreading Shield Fern

Life history**Growth form:** Terrestrial fern with long-creeping rhizome.**Vegetative spread:** Long-creeping rhizome forms large colonies.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing sporadic throughout the year, peak March.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Resents disturbance but small plants adapt to cultivation, will not tolerate drying of the root system (Jones & Clemesha 1981).]**Fire response:** Resprouts at ground level (Jones & Clemesha 1981).**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC CT ST; Qld, Vic., Tas.**Distribution Sydney area:** Upper Blue Mtns & Bundanoon, rare on Coast.**Select locations:** Woy Woy, Royal NP, Mt Wilson, Blackheath, Woodford, East Kangaloon, Bundanoon.**Habitat****Habitat:** Moist slopes, permanent moisture.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Open-forest or margins of rainforest.**Substrate:** Sandstone & basalt. Soil fertile–infertile. Moisture supply continuous, fresh.**Exposure:** Sheltered situations.**Conservation****Conservation:** Conservation status unknown.

Sticherus tener**GLEICHENIACEAE**

Silky Fan Fern

Life history

Growth form: Terrestrial fern with long-creeping rhizome. Shows considerable variation in both form and texture and this may be due to its possible hybrid origin. It has twice as many chromosomes as the other two species (Duncan & Isaac 1986).

Vegetative spread: Long-creeping rhizome forms large colonies.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing Dec-May, peak March.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Resents disturbance but small plants adapt to cultivation, will not tolerate drying of the root system (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC NT CT ?NWS; Vic., Tas.

Distribution Sydney area: Upper Blue Mtns & Bundanoon.

Select locations: Hazelbrook, Wentworth Falls, Blackheath, Mt. Wilson, Dargans Creek, Carrington Falls, Bundanoon, Minnamurra Falls.

Habitat

Habitat: Creek banks and sheltered gullies; cliff faces and near permanent moisture waterfalls.

Altitude: 200–1000 m **Annual rainfall:** above 1200 mm

Typical local abundance: Frequent.

Vegetation: Tall eucalypt open-forest or rainforest.

Substrate: Often in rock crevices, sandstone. Soil infertile. Water table permanently high, moisture supply continuous, fresh.

Exposure:

Conservation

Conservation: Conservation status unknown.

Grammitis billardieri**GRAMMITACEAE**

Finger Fern

Life history

Growth form: Small, tufted, epiphytic fern.

Vegetative spread: No.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing March–August.

Spore size 19–31 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Difficult to keep growing in cultivation (Jones & Clemesha 1981).]

Fire response: Probably killed.

Interaction with other organisms: Possibly requires association with mycorrhizal fungus for successful growth (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Qld, Vic., Tas., N.Z.

Distribution Sydney area: Blue Mountains and occasionally coastal.

Select locations: Cobscook Creek, Gympie Bay, Cambewarra, Springwood, Mt Wilson, Blackheath.

Habitat

Habitat: Epiphytic, near waterfalls or often in crevices near cliff faces.

Altitude: 0–1000 m **Annual rainfall:** above 1100 mm

Typical local abundance: Frequent–occasional.

Vegetation: Rainforest or moist open-forest.

Substrate: Epiphytic on mossy trees or rocks, on sandstone or basalt. Soil fertile or infertile. Moisture supply continuous, fresh.

Exposure: Sheltered situations; deep shade.

Conservation

Conservation: Conservation status unknown.

Hymenophyllum australe**HYMENOPHYLLACEAE****Life history**

Growth form: Small epiphytic fern.

Vegetative spread: Long-creeping rhizome, forms a dense mat of foliage.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores all year.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind. Probably no dormancy mechanism. All Hymenophyllaceae have short-lived spores — a lot start germinating whilst still on the fronds (E. Brown pers. comm.). [Easily grown in a terrarium (Jones & Clemesha 1981).]

Fire response: Probably killed by fire.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT; Qld, Vic., Tas.

Distribution Sydney area: Especially common in and to the south of the Blue Mountains.

Select locations: Gosford (1888), Mt Kembla (1891), Cambewarra (1886), Minnamurra Falls, Mountain Lagoon, Bowens Creek, Mt Wilson, Blackheath, Pierces Pass, Bundanoon.

Habitat

Habitat: Epiphytic or lithophytic, often along creeks.

Altitude: 0–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Occasional.

Vegetation: Rainforest or tall open-forest e.g. with *Ceratopetalum apetalum*, *Backhousia myrtifolia*.

Substrate: On damp rocks — mainly sandstone boulders, or decaying logs, or epiphytic on trees and tree ferns.

Exposure: Sheltered, deep shade.

Conservation

Conservation: Conservation status unknown.

Hymenophyllum bivalve**HYMENOPHYLLACEAE****Life history**

Growth form: Small epiphytic or terrestrial fern.

Vegetative spread: Long-creeping rhizome forms large patches.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores March–July.

Spore size 40–58 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT CT; Qld, N.Z.

Distribution Sydney area: Southern Illawarra.

Select locations: Upper Brogers Creek, above Minnamurra Falls.

Habitat

Habitat: Damp rocks near streams.

Altitude: 300–600 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Rainforest and wet eucalypt forest. Sometimes among mosses on rainforest floor (Tindale 1963).

Substrate: Forms large patches on boulders, old mossy tree trunks, damp rock faces and in clefts.

Exposure: Sheltered.

Conservation

Conservation: Regionally rare in Illawarra region (Mills 1988), Minnamurra Falls — southern limit.

Hymenophyllum cupressiforme**HYMENOPHYLLACEAE**

Common Filmy Fern

Life history**Growth form:** Epiphytic or terrestrial fern.**Vegetative spread:** Long-dreeping rhizome forms mats.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores all year but mainly March–May, August. Spore size 29–43 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. In dry times, fronds shrivel but usually refreshen with rain (Jones & Clemesha 1981). Easily grown in a pot (Jones & Clemesha 1981).**Fire response:** Killed by high intensity fire (Chesterfield, Taylor & Molnar 1990). Post-fire recruitment from spores.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST CWS; Qld, Vic., Tas.**Distribution Sydney area:** Blue Mountains and Illawarra.**Select locations:** Yarramalong, Middle Harbour Creek, Narrabeen, Waterfall, Loddon Falls, Fitzroy Falls, Minnamurra Falls, Woodhill, Mulgoa, Erskine Creek, Mt Tomah, Bowens Creek, Govetts Leap, Kanangra.**Habitat****Habitat:** Fern gullies and drier situations such as rock crevices, mine shafts and creek banks.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** In rainforest e.g. with *Acmena smithii* and protected sites in drier areas. Associated with mosses and hepatics.**Substrate:** Forms mats on rocks, often sandstone boulders but also on basalt, rotting logs, or trees, particularly tree ferns. Able to withstand short periods of drought and laminas uncurl during next rain (Tindale 1963).**Exposure:** Sheltered, deep shade.**Conservation****Conservation:** Widespread, probably adequately conserved.**Hymenophyllum flabellatum****HYMENOPHYLLACEAE**

Shiny Filmy Fern

Life history**Growth form:** small epiphytic or terrestrial fern.**Vegetative spread:** Long-creeping rhizome forms mats.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond, Dec–Sept. Spore size 33–47 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in a terrarium (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST; Qld, Vic., Tas., N.Z., Polynesia.**Distribution Sydney area:** Coastal ranges and Blue Mountains.**Select locations:** Watagan Mtns, Mt Wilson, Blackheath, Deep Pass, Upper Brogers Creek.**Habitat****Habitat:** On rocks or tree trunks, near waterfalls.**Altitude:** 0–1000 m**Annual rainfall:** above 1100 mm**Typical local abundance:** Rare–frequent.**Vegetation:** Rainforest and wet eucalypt forest.**Substrate:** Forms mats on rocks, ledges and boulder or tree ferns e.g. *Dicksonia antarctica*. Basalt. Moisture supply continuous. Appears to be very drought tolerant, often found on dry roof of overhanging rocks (in Tasmania) (Jarman *et al.* 1986).**Exposure:** Sheltered, deep shade.**Conservation****Conservation:** Conservation status unknown.

Hymenophyllum marginatum**HYMENOPHYLLACEAE**

Bordered Filmy Fern

Life history**Growth form:** Tiny mat-forming fern.**Vegetative spread:** Long-creeping rhizome forms mats.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond, January–June.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism.**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC NT CT; Qld, Tas.**Distribution Sydney area:** Upper Blue Mountains and Kiama area.**Select locations:** Wentworth Falls, Blackheath, Brogers Creek, Barren Grounds, Minnamurra Falls.**Habitat****Habitat:** Grows on rocks or logs, usually near creeks or foot of waterfalls in mist area.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Rainforest with *Ceratopetalum apetalum*.**Substrate:** On wet rocks, logs or soil in mist below falls. Moisture supply continuous, fresh.**Exposure:** Sheltered, deep shade.**Conservation****Conservation:** Regionally rare in Illawarra region (Mills 1988).

Conservation status elsewhere unknown.

Hymenophyllum pumilum**HYMENOPHYLLACEAE****Life history****Growth form:** Delicate epiphytic fern.**Vegetative spread:** Long-creeping rhizome forming mats.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC CT.**Distribution Sydney area:** Blue Mountains and Illawarra — uncommon.**Select locations:** Mt Tomah, Blackheath, Bowens Creek, Carrington Falls, Jamberoo Pass.**Habitat****Habitat:** Rainforest.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Rare.**Vegetation:** Cooler rainforest**Substrate:** Epiphytic on wet rocks and cliffs (Mills 1988).**Exposure:****Conservation****Conservation:** Uncommon, appears to be endemic to Sydney area.

Nationally coded 3RC (Briggs & Leigh 1988). Not conserved in Illawarra region (Mills 1988).

Hymenophyllum rarum

HYMENOPHYLLACEAE

Narrow Filmy Fern

Life history**Growth form:** Epiphytic or terrestrial fern.**Vegetative spread:** Long-creeping rhizome forms large patches on boulders, tree trunks.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores May–July.

Spore size 30–51 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily maintained in a terrarium (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT; Vic., Tas., N.Z.**Distribution Sydney area:** Blue Mountains and Illawarra.**Select locations:** Mt Wilson, Upper Brogers Creek, Upper Minnamurra Falls.**Habitat****Habitat:** Damp rocks near streams.**Altitude:** 600–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Rare–frequent.**Vegetation:** in rainforest or moist gullies.**Substrate:** On damp rocks, also epiphytic on trees or tree ferns.**Exposure:** Sheltered, deep shade.**Conservation****Conservation:** Regionally rare in Illawarra region (Mills 1988). Conservation status unknown.**Polyphlebium venosum**

HYMENOPHYLLACEAE

Life history**Growth form:** Epiphytic fern.**Vegetative spread:** Creeping rhizome, forms densely matted patches.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond, December–May.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily maintained on a piece of *Dicksonia antarctica* trunk (Jones & Clemesha 1981).]**Fire response:** Killed by high intensity fire (Chesterfield, Taylor & Molnar 1990).**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST; Qld, Vic., Tas., N.Z.**Distribution Sydney area:** Blue Mountains and Illawarra.**Select locations:** Narrabeen Lake (1887), Cambewarra (1886), Minnamurra Falls, Mt Tomah, Mt Wilson, Mt Irvine, Leura Falls (1903), Jenolan Caves (1899).**Habitat****Habitat:** Common on logs and tree trunks, especially on *Dicksonia antarctica*.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Occasional–frequent.**Vegetation:** Rainforest, epiphytic on trunks of *Dicksonia antarctica* in particular, but also *Cyathea*.**Substrate:** Moisture supply continuous, fresh. Soil fertile.**Exposure:** Sheltered, deep shade.**Conservation****Conservation:** Conservation status unknown.

Sphaerocionium lyallii**HYMENOPHYLLACEAE****Life history**

Growth form: Epiphytic fern with long-creeping, mat-forming rhizomes.

Vegetative spread: Creeping rhizome forms dense mats.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond, May–October.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism.

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC CT ST; N.Z.

Distribution Sydney area: Blue Mountains and Illawarra region.

Select locations: Coledale, Macquarie Pass (Mills 1988), Cambewarra, Minnamurra, Barren Grounds, Mt Wilson, Wentworth Falls, Katoomba.

Habitat

Habitat: On damp rocks or trees, in deep gullies.

Altitude: 0–1000 m **Annual rainfall:** above 1200 mm

Typical local abundance: Frequent.

Vegetation: Moist rainforest with other fern species.

Substrate: Epiphytic on trees, e.g. on old *Ceratopetalum apetalum*, or base of *Todea barbara*, also on wet rocks and cliffs amongst other small ferns (Mills 1988). May be within mist of waterfalls.

Exposure: Sheltered, deep shade.

Conservation

Conservation: Rare, nationally coded 3RC (Briggs & Leigh 1988). Mills reports that the small number of records suggest that it is quite rare in the region and in NSW (Mills 1988).

Lindsaea dimorpha**LINDSAEACEAE****Life history**

Growth form: Terrestrial fern with short-creeping rhizome.

Vegetative spread: Limited.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Recruitment mainly after fire (D. Keith pers. comm.). [Very difficult to cultivate (Jones & Clemesha 1981).]

Fire response: Resprouts (D. Keith pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC; Qld, N.Cal.

Distribution Sydney area: Coastal, north from Jervis Bay; rare.

Select locations: Somersby, Dharug NP, Mulgoa, Nowra, Huskisson (southern limit).

Habitat

Habitat: Damp places.

Altitude: 0–200 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent–rare.

Vegetation: Heath.

Substrate: Shallow sandy soil, sandstone. Water table mostly high, fresh.

Exposure:

Conservation

Conservation: Rare. Vulnerable in Western Sydney (Benson & McDougall 1991). Conservation status unknown.

Lindsaea linearis**LINDSAEACEAE**

Screw Fern

Life history**Growth form:** Terrestrial fern with short-creeping rhizome.**Vegetative spread:** Vegetative spread is by a fine rhizome, forms small colonies, spread c. 30 cm.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond, sporing peak July–September.

Recruitment mainly after fire (D. Keith pers. comm.). Spore size 22–35 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, no special morphology (Westoby *et al.* 1990), probably no dormancy mechanism. [Very difficult to establish or keep growing (Jones & Clemesha 1981).]**Fire response:** Resprouts at ground level or below.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST; Qld, Vic., Tas., S.A., W.A., N.I., N.Z., N.Cal.**Distribution Sydney area:** Coast and Blue Mountains.**Select locations:** Catherine Hill Bay, Gosford, Terrey Hills, La Perouse, Darkes Forest, Nowra, Lawson, Blaxland, Fitzroy Falls, Bundanoon, Barren Grounds.**Habitat****Habitat:** Moist areas.**Altitude:** 30–1000 m**Annual rainfall:** 800–1200 mm**Typical local abundance:** Occasional.**Vegetation:** Eucalypt open-forest, heath or near swamps.**Substrate:** Often among rocks, clay flats, infertile or very infertile soils, sandstone.

Water table mostly high. Non-saline.

Exposure: Exposed.**Conservation****Conservation:** Probably adequately conserved.**Lindsaea microphylla****LINDSAEACEAE**

Lacy Wedge Fern

Life history**Growth form:** Terrestrial fern with short-creeping rhizome.**Vegetative spread:** Spreads by rhizome.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores at any time, peak August (Coast), April (mountains).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Sometimes colonizing man-made excavations especially in micaceous clay soils (Jones & Clemesha 1981). [Very difficult to establish or keep growing (Jones & Clemesha 1981).]**Fire response:** Resprouts at ground level or below.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT; Qld, Vic.**Distribution Sydney area:** Coast and Blue Mtns, common.**Select locations:** Wollombi, Bouddi, Bobbin Head, Cheltenham, Garie, Wingello, Springwood, Mulgoa, Mt. Wilson, Cudgegong, Hilltop.**Habitat****Habitat:** Moist, rocky places, hillsides, or near creeks.**Altitude:** 0–1000 m**Annual rainfall:** above 400 mm**Typical local abundance:** Frequent–occasional–rare.**Vegetation:** Woodland, open-forest & along rainforest margins.**Substrate:** Sandy soil from sandstone, infertile–very infertile. Water table mostly high, moisture supply intermittent, fresh.**Exposure:** Sheltered situations; light shade.**Conservation****Conservation:** Probably adequately conserved.

Lindsaea trichomanoides**LINDSAEACEAE**

Growth form: Terrestrial fern with creeping rhizome.

Vegetative spread:

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spore size 16–23 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism.

Fire response:

Interaction with other organisms:

Life history

Status/origin: Native.

Botanical subregions: ?NC CC CT; Vic., Tas., N.Z.

Distribution Sydney area: Chiefly in coastal situations south of Sydney; not common.

Select locations: Kurrajong, Burralow Swamp (P. Hind pers. comm.), Mt Keira, Kiama, Minnamurra.

Distribution

Habitat: Wet gullies.

Altitude: 0–600 m

Annual rainfall: above 1200 mm

Typical local abundance: Rare.

Vegetation: Moist forest, rainforest. On creeks with *Libbertia*.

Substrate: Rocky areas. No salinity. On peaty soil and logs (in Tasmania) (Jarman *et al.* 1986).

Exposure: Sheltered situations.

Habitat

Conservation: Rare. Regionally rare in Illawarra region (Mills 1988).

Conservation status elsewhere unknown.

Conservation**Lycopodium cernuum****LYCOPODIACEAE**

Scrambling Clubmoss

Growth form: Terrestrial, creeping plant; scrambling aerial stems with simple leaves and subterranean stems with wiry roots.

Vegetative spread: Main stem creeping over ground surface, rooting at intervals.

Longevity: Indefinite.

Reproduction: Sporangia in cone-like strobili. Sporing peak August–September (limited data). Spore size 18–27 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind; long-lived.

Spores only germinate in the absence of light and remain dormant until buried; mycorrhizal fungi aid development of subterranean prothallus, maturity may take 10–15 years (Jones 1987). [Very difficult to transplant but easy once growing (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Life history

Status/origin: Native.

Botanical subregions: NC CC NT; Qld, N.T., W.A., pantrop.

Distribution Sydney area: Coastal.

Select locations: Watagan Mtns, Gosford, McCarrs Ck, Meadowbank, Royal NP.

Distribution

Habitat: On moist cliff faces, road cuttings, or open areas or swamp edges.

Altitude: 0–300 m

Annual rainfall: above 1000 mm

Typical local abundance:

Vegetation: Sclerophyll forest.

Substrate: Sandstone, very infertile soil. Water table permanently high, moisture supply continuous, fresh.

Exposure: Mid–no shade.

Habitat

Conservation: Conservation status unknown.

Conservation

Lycopodium deuterodensum**LYCOPODIACEAE**

Bushy Clubmoss

Life history

Growth form: Terrestrial or epiphytic plant; stems erect to 90 cm high with simple leaves and subterranean main stems with wiry roots.

Vegetative spread:

Longevity: Indefinite.

Reproduction: Sporangia in cone-like strobili. Spores at any time, except June, peak March.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind; long-lived. Spores only germinate in the absence of light and remain dormant until buried; mycorrhizal fungi aid development of subterranean prothallus, maturity may take 10–15 years (Jones 1987). [Impossible to grow (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Qld. Vic., Tas., S.A., N.I., N.Cal.

Distribution Sydney area: Widespread, Coast & Upper Blue Mtns.

Select locations: Gosford, Terrey Hills, Royal NP, Minnamurra Falls, Wentworth Falls, Clarence, Jenolan Caves, Kanangra.

Habitat

Habitat: Various situations, hillsides, sometimes swampy.

Altitude: 0–1200 m

Annual rainfall: above 1200 mm

Typical local abundance: Occasional.

Vegetation: Eucalypt woodland, mallee and heath.

Substrate: Sandy soils, sandstone, infertile. Water table mostly high or mostly low, moisture supply intermittent, fresh.

Exposure: Sheltered situations; mid shade.

Conservation

Conservation: Conservation status unknown.

Lycopodium laterale**LYCOPODIACEAE**

Slender Clubmoss

Life history

Growth form: Terrestrial or epiphytic plant; weak stems with simple leaves and subterranean main stems with wiry roots.

Vegetative spread: Subterranean main stems.

Longevity: Indefinite.

Reproduction: Sporangia in cone-like strobili. Spores at any time, peak April, August.

Spore size 31–47 μm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind; long-lived. Spores only germinate in the absence of light and remain dormant until buried; mycorrhizal fungi aid development of subterranean prothallus, small swollen bodies formed near the soil surface are both photosynthetic and mycorrhizic; maturity of the prothallus may take 10–15 years (Jones 1987). Recruitment mainly after fire (D. Keith pers. comm.). [Can be successfully grown but very slow (Jones & Clemesha 1981).]

Fire response: Resprouts (D. Keith pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT; Qld, Vic., Tas., S.A., N.Z., N.Cal.

Distribution Sydney area: Widespread, Coast & Blue Mtns.

Select locations: Gosford, Cowan, Roseville, Austinmer, Maddens Plains, Minnamurra Falls, Bilpin, Woodford, Katoomba, Gaspers Mtn.

Habitat

Habitat: Wet boggy areas.

Altitude: 0–1200 m

Annual rainfall: above 900 mm

Typical local abundance: Occasional.

Vegetation: Sedge swamps and wet heath.

Substrate: Soaks below sandstone cliff lines. Infertile soil. Water table mostly high, moisture supply intermittent, fresh.

Exposure: Indifferent–sheltered; light–no shade.

Conservation

Conservation: Conservation status unknown.

Marsilea costulifera (*M. angustifolia*)**MARSILEACEAE****Life history**

Growth form: Fern with slender, creeping rhizomes, rooting at nodes.

Vegetative spread: Forms patches (Jones 1993).

Longevity: Indefinite.

Reproduction: Spores produced in sori within a thick-walled, nut-like sporocarp which arises from rhizome at base of frond.

Dispersal, establishment & growth: Diaspore: sporocarps; probably water-dispersed.

Fire response: Not likely to be burnt but would probably resprout from rhizome.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC NT CT SWS NWP SWP NFWP; Qld, Vic., S.A. Does not overlap with *M. angustifolia* which is tropical in N.T., W.A. (Jones 1993).

Distribution Sydney area: Western Sydney.

Select locations: Doonside (1967), Glenfield (1952). Not all Herbarium records available.

Habitat

Habitat: Wet places; emergent zone, permanent or semi-permanent freshwater swamp.

Altitude: 0–200 m

Annual rainfall: 700–1000 mm

Typical local abundance: Abundance probably fluctuates depending on rainfall and flooding. Locally common (Jones 1993).

Vegetation: Semi-permanent freshwater swamp.

Substrate: Floodplain alluvium. In mud, shallow water and moist depressions (Jones 1993).

Exposure:

Conservation

Conservation: Possibly extinct in Western Sydney (Benson & McDougall 1991), though widely distributed, and probably well conserved elsewhere (Jones 1993).

Marsilea hirsuta**MARSILEACEAE****Life history**

Growth form: Rhizomatous, semi-aquatic fern with hairy, small clover-like fronds.

Vegetative spread: Creeping rhizome rooting at nodes.

Longevity: Indefinite.

Reproduction: Spores produced in sori within a thick-walled, nut-like sporocarp which arises from rhizome at base of frond. Probably requires an emergent period to develop sporocarps. [Produces sporocarps readily in cultivation (P. Lister pers. comm.).]

Dispersal, establishment & growth: Diaspore: sporocarps; probably water-dispersed. Abundance probably fluctuates depending on rainfall and flooding. Probably no spore dormancy.

Fire response: Not likely to be burnt but would probably resprout from rhizome.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC ST NWS CWS SWS NWP NFWP SFWP; Qld, Vic., N.T., S.A., W.A.

Distribution Sydney area: Western Sydney.

Select locations: Richmond, Yarramundi, Penrith, Doonside, Glenfield, Kemps Creek, Narellan.

Habitat

Habitat: Wet places; ephemeral watercourses and ditches.

Altitude: 0–50 m

Annual rainfall: 700–800 mm

Typical local abundance: Frequent.

Vegetation: Fresh meadow with herbaceous species e.g. *Juncus articulatus*, *Amphibromus*, *Ranunculus*, *Pratia*.

Substrate: Floodplain alluvium, fertile soil, semi-permanent or ephemeral watercourses and soakage areas.

Exposure: Mid-light shade, 10–60 % Projective Foliage Cover (P. Lister pers. comm.)

Conservation

Conservation: Not adequate. Vulnerable in Western Sydney (Benson & McDougall 1991).

Marsilea mutica**MARSILEACEAE****Life history**

Growth form: Rhizomatous, semi-aquatic, perennial fern with clover-like fronds on stems up to 1 m long. Reproduces sexually & vegetatively.

Vegetative spread: Creeping rhizome rooting at nodes.

Longevity: Indefinite.

Reproduction: Spores produced in sori within a thick-walled, nut-like sporocarp which arises from rhizome at base of frond. Probably requires an emergent period to develop sporocarps.

Dispersal, establishment & growth: Diaspore: sporocarps; probably water-dispersed. Probably no spore dormancy but sporelings only developed after sporocarps were cracked open. First leaves visible in 5–7 days (Yen & Myerscough 1989). Abundance probably fluctuates depending on rainfall and flooding.

Fire response: Not likely to be burnt but would probably resprout from rhizome.

Interaction with other organisms: In competition with other species, *M. mutica* is possibly the most resistant to wind and waves but least strong competitor for available water surface under sheltered conditions (Yen & Myerscough 1989 a, b) at Bushells Lagoon.

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST NWP; Qld, Vic., Tas., N.T., S.A., W.A., N. Cal.

Distribution Sydney area: Mainly Western Sydney.

Select locations: Wollombi Brook, Cooranbong, Pitt Town, Richmond (Pughs Lagoon), St Albans, Werrington, Glenfield, Narellan, Port Kembla.

Habitat

Habitat: Wet places.

Altitude: 0–50 m **Annual rainfall:** above 600 mm

Typical local abundance: Occasional.

Vegetation: Emergent zone; permanent or semi-permanent freshwater swamp.

Substrate: Floodplain alluvium in water 1–150 cm deep.

Exposure: Full sun.

Conservation

Conservation: Not adequate, has disappeared from Longneck Lagoon since 1976.

Vulnerable in Western Sydney (Benson & McDougall 1991).

Pilularia novae-hollandiae**MARSILEACEAE**

Austral Pillwort

Life history

Growth form: Tiny, semi-aquatic, grass-like fern to 8 cm high with rhizome rooting at node, turf forming.

Vegetative spread: Spreads by rhizome rooting at nodes.

Longevity: Indefinite.

Reproduction: Spores produced in sori within a thick-walled, nut-like sporocarp which arises from rhizome at base of frond.

Dispersal, establishment & growth: Diaspore: sporocarps, juveniles submerged, adults submerged, emergent or temporarily terrestrial (Cook 1990). Probably no spore dormancy.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC ST SWS; Vic., Tas., SA.

Distribution Sydney area: Western Sydney.

Select locations: Doonside (1966, only record for area).

Habitat

Habitat: In a dried out roadside ditch, not plentiful (1966).

Altitude: 50 m **Annual rainfall:** 800 mm

Typical local abundance: Rare.

Vegetation: Sedgeland e.g. *Juncus*, *Elatine*, *Melaleuca*.

Substrate: Clay soil.

Exposure:

Conservation

Conservation: Rare, not conserved.

Vulnerable in Western Sydney (Benson & McDougall 1991).

Botrychium australe**OPHIOGLOSSACEAE**

Parsley Fern

Life history

Growth form: Perennial herb to 50 cm high, with deeply buried non-creeping rhizome and fleshy roots. Frond usually solitary 7–50 cm high; not coiled when young (Jones 1987).

Vegetative spread: No.

Longevity: Indefinite.

Reproduction: Frond with fertile and sterile segments; spores produced in sporangia on lower surface. Sporing period peak April–May. Spore size 22–33 μm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Light inhibits germination of spores, must be covered with humus or washed into holes or cracks (Jones 1987). Subterranean prothallus lacks chlorophyll, requires mycorrhizal fungus to develop; may persist in soil for 20 years (Jones 1987). [Easily cultivated; no record of ferns being raised from spores (Jones & Clemesha 1981).]

Fire response: Resprouts at ground level or below (1 report).

Interaction with other organisms: Association with mycorrhizal fungus essential at all stages of development (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT; LHI, Qld, Vic., Tas., S.A., N.Z.

Distribution Sydney area: Generally coastal, rare.

Select locations: Martinsville, Watagan Mtns (P. Hind), Newport, Mosman, Sandy Point, Long Swamp (Kodala *et al.* 1992), Minnamurra Falls, Blue Gum Forest, Yerranderie (P. Hind pers. comm.).

Habitat

Habitat: Damp sites, near creeks; margin of upland mire (Kodala 1992).

Altitude: 30–620 m

Annual rainfall: above 1000 mm

Typical local abundance: Rare.

Vegetation: Open-forest or grassy places on edge of rainforest. Swamp margin at base of slope amongst *Lomandra longifolia* (Kodala *et al.* 1992).

Substrate: Sandy soil on sandstone. Soil fertile or infertile. Damp sites with intermittent moisture supply. No salinity.

Exposure: Sheltered situations; mid-light shade.

Conservation

Conservation: Rare, likely to be poorly conserved. Although widespread, is uncommon and considered rare by Tindale (1982) (Kodala *et al.* 1992).

Ophioglossum lusitanicum subsp. **coriaceum**

OPHIOGLOSSACEAE

Adder's Tongue

Life history

Growth form: Terrestrial herb 3–15 cm high, with deeply buried knobby rootstock and fleshy roots. Fronds usually 1–5; not coiled when young (Jones 1987).

Vegetative spread: No.

Longevity: Indefinite.

Reproduction: Fertile spike on stalk to 8 cm long, spores produced in sporangia on lower surface. Sporing period? (inadequate material).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Light inhibits germination of spores, must be covered with humus or washed into holes or cracks (Jones 1987). Subterranean prothallus lacks chlorophyll, requires mycorrhizal fungus to develop; may persist in soil for 20 years (Jones 1987). [Difficult to cultivate (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms: Association with mycorrhizal fungus essential at all stages of development (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NFWP; Qld, Vic., Tas., N.T., S.A., W.A., cosmop.

Distribution Sydney area: Coast and Dividing Range — rare.

Select locations: Woy Woy, Riverstone, Royal NP, Casula, Rylstone, Gardiners Gap, Boyd Crossing.

Habitat

Habitat: Damp open sites, in grassland or amongst mossy rocks.

Altitude: 0–1200 m

Annual rainfall: 800–1400 mm

Typical local abundance: Occasional, rare.

Vegetation: Open grassland, freshwater swamps or in peaty soil in heathland.

Substrate: Peaty soil, rock platforms in skeletal soil or sandstone granite or basalt. Soil infertile, damp. Moisture supply intermittent, fresh.

Exposure: Exposed–indifferent; light–no shade.

Conservation

Conservation: Rare. Vulnerable in Western Sydney (Benson & McDougall 1991).

Leptopteris fraseri

OSMUNDACEAE

Life history

Growth form: Terrestrial fern with arborescent trunk to 1 m high.

Vegetative spread:

Longevity: Indefinite.

Reproduction: Spores green, produced in sporangia on lower surface of frond, August–May, peak March–April; lose viability within hours (Jones & Clemesha 1981).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in protected places (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT CT ST; Qld.

Distribution Sydney area: Chiefly on the ranges, Upper Blue Mtns and Minnamurra.

Select locations: Mt Wilson, Blackheath, Wentworth Falls, Barren Grounds, Minnamurra Falls, Belmore Falls.

Habitat

Habitat: Very wet places in caves, often near waterfalls, rocky mountain gullies.

Altitude: 0–1100 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Cooler rainforest.

Substrate: Moisture supply continuous.

Exposure: Sheltered situations.

Conservation

Conservation: Regionally rare in Illawarra region (Mills 1988).

Conservation status elsewhere unknown.

Todea barbara**OSMUNDACEAE**

King Fern

Life history**Growth form:** Terrestrial fern with arborescent trunk to 3 m high, slow growing.**Vegetative spread:** Limited, old specimens have trunks to 2 m in diameter with numerous crowns.**Longevity:** Indefinite.**Reproduction:** Spores produced in sporangia on lower surface of frond, green and contain chlorophyll; lose viability within hours (Jones & Clemesha 1981). Spore size 47–78 µm (Tryon & Lugardon 1991), peak September–October. Massive spore release in Dec ? in NZ (E. Brown pers. comm.).

Spore size 43–62 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores, dispersed by wind, probably no dormancy mechanism; germinates in light, prothallus capable of photosynthesis (Jones 1987). Slow growing. [Vigorous colonizer of damp, partly cleared sites, does well in cultivation (Duncan & Isaac 1986).**Fire response:****Interaction with other organisms:** Trunk often bears epiphytes. Exploited as source of growing medium (trunks) for orchids, ferns etc. (Jones 1987).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS; Qld, Vic., Tas., S.A., N.Z., S. Africa.**Distribution Sydney area:** Widespread especially in the ranges.**Select locations:** Calga, Royal NP, Mt Kembla, Springwood, Blackheath, Mt Wilson, Rylstone, Bundanoon, Fitzroy Falls.**Habitat****Habitat:** Damp places, often along streams.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Tall open-forest, less commonly rainforest gullies.**Substrate:** Crevices of sandstone cliffs, creek banks; also on granite. Soil fertile–infertile.

Water table mostly high, moisture supply continuous.

Exposure: Sheltered situations; mid shade.**Conservation****Conservation:** Conservation status unknown.

Dictymia brownii

POLYPODIACEAE

Life history

Growth form: Epiphytic fern with rhizome creeping, green and frequently branched.

Vegetative spread: Long-creeping rhizome forming large clumps.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Sporing period ? (inadequate material). In established clumps, majority of fronds bear abundant sori although number of spores released do not seem high (Walker & Page 1982).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown (Jones & Clemesha 1981).]

Fire response: Probably killed.

Interaction with other organisms: The rhizome and root masses trap detritus and are often colonized by mosses, epiphytic ferns and orchids, creating a small reservoir of moisture (Walker & Page 1982).

Distribution

Status/origin: Native.

Botanical subregions: NC CC CT ST; Qld.

Distribution Sydney area: Chiefly ranges north from the Blue Mountains. Colo area, Otford and upper Blue Mountains.

Select locations: Crawfords Lookout, Dharug NP, Brisbane Water NP, Otford, Wentworth Falls.

Habitat

Habitat: Epiphytic on rocks or tree trunks, in shady gullies.

Altitude: 0–900 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Over its range: in dense rainforest, confined to epiphytic sites in highest canopy and in more open rainforest on branches in crowns of trees and on upper trunks of palms (Walker & Page 1982). Sydney area, in or near rainforest.

Substrate: Often forming large clumps on rocks or tree trunks, sandstone. Soil fertile. On mountains where there is frequent cloud and high humidity but can withstand moderate desiccation for periods during middle of day (Walker & Page 1982).

Exposure: Sheltered situations; mid shade. Seems to be considerably light-demanding (Walker & Page 1982).

Conservation

Conservation: Rare, regionally rare in Illawarra region (Mills 1988), Otford southern limit. Conservation status unknown.

Microsorium pustulatum (M. diversifolium)

POLYPODIACEAE

Kangaroo Fern

Life history

Growth form: Epiphytic fern.

Vegetative spread: Very long-creeping rhizome forms mats.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond. Spores at any time, peak August.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in a protected site (Jones & Clemesha 1981. High rainfall areas from coast to subalpine regions.)]

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC SC NT CT ST; Qld, Vic., Tas., N.I., N.Z.

Distribution Sydney area: Upper Blue Mountains and southwards.

Select locations: Mt Coricudgy, Mt Tomah, Mt Wilson, Blackheath, Ruby Creek, Robertson, Bundanoon.

Habitat

Habitat: On rocks or tree trunks in shady situations.

Altitude: 700–1000 m

Annual rainfall: above 1400 mm

Typical local abundance: Frequent–occasional.

Vegetation: In or near rainforest.

Substrate: Rocks or tree trunks, occasionally as ground cover on forest floor, basalt. Soil very fertile, fertile. No salinity.

Exposure: Sheltered situations.

Conservation

Conservation: Conservation status unknown.

Microsorium scandens**POLYPODIACEAE**

Fragrant Fern

Life history**Growth form:** Creeping epiphytic fern with fragrance of cumin when bruised (P. Hind pers. comm.).**Vegetative spread:** Very long-creeping rhizome forms mats.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores at any time, peak March (mountains), November (coast).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in protected situations and useful ground cover in dark situations (Jones & Clemesha 1981).]**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST CWS; LHI, Qld, Vic., N.Z.**Distribution Sydney area:** Coast and Blue Mountains, widespread.**Select locations:** Watagan Mtns, Gosford, Otford, Jamberoo, St Helena, Mt Tomah, Mt Wilson, Bundanoon.**Habitat****Habitat:** Epiphytic on boulders or tree trunks, in sheltered gullies.**Altitude:** 0–1000 m**Annual rainfall:** generally above 1400 mm**Typical local abundance:** Frequent.**Vegetation:** In rainforest and fern gullies; rainforest low-climber.**Substrate:** On boulders, mossy tree trunks and tree ferns or as ground cover on sloping river banks; mostly basalt, less commonly sandstone. Soil very fertile–fertile. No salinity.**Exposure:** Sheltered situations.**Conservation****Conservation:** Conservation status unknown.**Platycerium bifurcatum subsp. bifurcatum** **POLYPODIACEAE**

Elkhorn

Life history**Growth form:** Epiphytic bracket fern, forming 'nest', with dimorphic fronds and short thick rhizome.**Vegetative spread:** Very limited — plantlets grow from buds on the outer lower margins and enable the clump to circle the tree.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very easily grown, hardy in open as far south as Melbourne (Jones & Clemesha 1981).]**Fire response:** Probably killed.**Interaction with other organisms:** Host plant of *Halticoriscus platyceryi* Staghorn Beetle and Staghorn Borer (Jones & Elliot 1986). Reported as epiphytic on *Casuarina*. Other epiphytics frequently grow on the 'nests'.**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC; LHI, Qld, N.G.**Distribution Sydney area:** Coastal — now rare but reported 'plentifully about the trees and rocks in shady places in the vicinity of Port Jackson' (Bennett 1860).**Select locations:** Gosford, Blakehurst (1902), Austinmer, Nowra, Shoalhaven.**Habitat****Habitat:** Usually epiphytic on trees or on boulders and rock faces.**Altitude:** 0–500 m**Annual rainfall:** 1200–1600 mm**Typical local abundance:** Rare.**Vegetation:** Rainforest, sometimes swamp forest or open-forest.**Substrate:** Soil fertile. Water table permanently low, moisture supply intermittent, brackish or fresh.**Exposure:** Sheltered situations; mid-light shade.**Conservation****Conservation:** Native to coastal rainforest and swamp forest but now found sometimes as naturalized in bushland near houses (e.g. Nth Head, as escape from cultivation. Evidently once more common (Bennett 1860, see above) but probably extensively collected for horticultural purposes.

Pyrrosia confluens**POLYPODIACEAE**

Horseshoe Felt Fern

Life history**Growth form:** Small epiphytic fern with dimorphic fronds and creeping rhizome.**Vegetative spread:** Long-creeping rhizome allows limited spread on host tree.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown (Jones & Clemesha 1981).] During drought fronds may curl and shrivel but will swell again with rain.**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT NWS CWS; LHI, Qld, N.I., N.Cal.**Distribution Sydney area:** North from the Wyong area.**Select locations:** Ourimbah, Calga, Wentworth Falls (very old record).**Habitat****Habitat:** Epiphytic on tree branches and trunks, other epiphytes or rocks.**Altitude:** 0–900 m**Annual rainfall:** above 1200 mm**Typical local abundance:****Vegetation:** Rainforest.**Substrate:** Rocks or tree trunks, soil fertile, basalt. Water table permanently low, moisture supply intermittent, fresh.**Exposure:** Sheltered situations; deep shade.**Conservation****Conservation:** Very rare in the area, only 3 records. Conservation status unknown.**Pyrrosia rupestris****POLYPODIACEAE**

Rock Felt Fern

Life history**Growth form:** Small epiphytic fern with dimorphic fronds and creeping rhizome.**Vegetative spread:** Long-creeping rhizome allows limited spread on host.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores at any time; peak August, December. Spore size 56–87 µm diameter.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Dispersal: no special morphology (Westoby *et al.* 1990). [Easily grown (Jones & Clemesha 1981).] In times of drought fronds may curl and shrivel but will swell again with rain.**Fire response:** Killed by high intensity fire (Chesterfield, Taylor & Molnar 1990).**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS; Qld, N.G.**Distribution Sydney area:** Widespread, north from Nadgee.**Select locations:** Watagan Mtns, Boudi, Eastwood, Menangle, Wollongong, Cambewarra, Mt Coricudgy, Springwood, Mt Wilson, Robertson, Bundanoon, Wombeyan.**Habitat****Habitat:** Epiphytic on tree trunk and branches or rocks.**Altitude:** 0–1000 m**Annual rainfall:** 800–1400 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Rainforest, open-forest.**Substrate:** Epiphytic, also rocks in exposed situations; sandstone, basalt, granite. Water table permanently low, moisture supply intermittent, fresh.**Exposure:** Sheltered.**Conservation****Conservation:** Conservation status unknown.

Psilotum nudum**PSILOTACEAE**

Skeleton Fork Fern

Life history**Growth form:** Terrestrial or epiphytic plant with short-creeping rhizome, lacking roots.**Vegetative spread:** Limited.**Longevity:** Indefinite.**Reproduction:** Sporing March–Nov, peak Sept–Oct. Spore size 22–40 µm (Large & Braggins 1991).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. The gametophytes are colourless, subterranean, very slow growing and depend on an associated fungus which lives in their tissues; they have never been cultivated and rarely have been seen (C. Chambers pers. comm.). [A hardy but slow-growing plant in cultivation (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT NWS CWS; Qld, Vic., N.T., W.A., N.Z., trop, Japan.**Distribution Sydney area:** Rare away from coastal areas. North of the Shoalhaven River.**Select locations:** Mt Yengo, Central Colo, Gosford, McCarrs Ck, Deep Ck, Castle Cove, Sydney Opera House, Royal NP, The Woolwash, Bundanoon.**Habitat****Habitat:** Usually found tufted in rock crevices.**Altitude:** 0–500 m**Annual rainfall:** above 800 mm**Typical local abundance:** Rare.**Vegetation:** Eucalypt open-forest or tall open forest.**Substrate:** Crevices of sandstone rocks or cliffs. Soil infertile. Water table mostly low, moisture supply intermittent, fresh.**Exposure:** Sheltered situations.**Conservation****Conservation:** Conservation status unknown.**Tmesipteris obliqua** (T. billardieri nom. illeg.) **PSILOTACEAE****Life history****Growth form:** Pendent epiphyte, rarely terrestrial, aerial shoots usually 20–40 cm long; long-creeping rhizome, without roots.**Vegetative spread:** Limited.**Longevity:** Indefinite.**Reproduction:** Sporing November–August, peak March (limited data).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. The gametophytes are colourless, subterranean, very slow growing and depend on an associated fungus which lives in their tissues; they have never been cultivated and rarely have been seen (C. Chambers pers. comm.). [Cultivation unknown (Jones & Clemesha 1981).]**Fire response:** Killed by high intensity fire (Chesterfield, Taylor & Molnar 1990).**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC CT ST; Vic., Tas.**Distribution Sydney area:** Upper Blue Mountains & Minnamurra.**Select locations:** Kurrajong Heights, Mt Tomah, Mt Irvine, Mt Wilson, Minnamurra Falls.**Habitat****Habitat:** Usually epiphytic on trunks and bases of treeferns, or rocks along creeks.**Altitude:** 200–1000 m**Annual rainfall:** above 1400 mm**Typical local abundance:** Occasional–rare.**Vegetation:** Rainforest or rarely tall eucalypt forest.**Substrate:** Usually epiphytic on treeferns, *Cyathea* and *Dicksonia antarctica*, or on rocks; also in humus accumulations on banks and around tree bases (Chinnock 1993). Basalt soils, very fertile. Moisture supply intermittent, fresh.**Exposure:** Sheltered situations.**Conservation****Conservation:** Regionally rare in Illawarra region (Mills 1988), conservation status unknown.

Tmesipteris ovata**PSILOTACEAE****Life history**

Growth form: Pendent epiphyte with aerial stems and long-creeping rhizome without roots.

Vegetative spread: Limited.

Longevity: Indefinite.

Reproduction: Sporing January (limited records).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. The gametophytes are colourless, subterranean, very slow growing and depend on an associated fungus which lives in their tissues; they have never been cultivated and rarely have been seen (C. Chambers pers. comm.). [Cultivation unknown (Jones & Clemesha 1981).]

Fire response: Killed by high intensity fire (Chesterfield, Taylor & Molnar 1990).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT; Qld, Vic., Tas. (King Is).

Distribution Sydney area: Only two Herbarium records.

Select locations: Blackheath, Minnamurra Falls.

Habitat

Habitat: Usually epiphytic on treeferns.

Altitude: 0–1000 m **Annual rainfall:** above 1400 mm

Typical local abundance: Frequent.

Vegetation: Rainforest.

Substrate: Usually epiphytic on treeferns e.g. *Cyathea australis*. Soil fertile. Water table permanently high, moisture supply intermittent, fresh.

Exposure: Sheltered situations.

Conservation

Conservation: Rare. Regionally rare in Illawarra region (Mills 1988), conservation status elsewhere unknown.

Tmesipteris parva**PSILOTACEAE****Life history**

Growth form: Pendent epiphyte with aerial stems and long-creeping rhizome without roots.

Vegetative spread:

Longevity: Limited.

Reproduction: Spores August–September.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. The gametophytes are colourless, subterranean, very slow growing and depend on an associated fungus which lives in their tissues; they have never been cultivated and rarely have been seen (C. Chambers pers. comm.). [Cultivation unknown (Jones & Clemesha 1981).]

Fire response: Killed by high intensity fire (Chesterfield, Taylor & Molnar 1990).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST; Qld, Vic.

Distribution Sydney area: Blue Mountains, but not common.

Select locations: Mt Wilson, Glenbrook, Cambewarra. Not all Herbarium records available.

Habitat

Habitat: Usually epiphytic on tree ferns.

Altitude: 0–1000 m **Annual rainfall:** above 1000 mm

Typical local abundance: Occasional.

Vegetation: Epiphytic on *Cyathea* and *Dicksonia antarctica* trunks in rainforest and moist eucalypt forest.

Substrate: Usually epiphytic on treeferns, high nutrient soils, basalt.

Exposure: Sheltered.

Conservation

Conservation: Regionally rare in Illawarra region (Mills 1988), probably rare at other localities.

Tmesiteris truncata**PSILOTACEAE****Life history**

Growth form: Epiphytic or terrestrial fern with aerial stems and long-creeping rhizome without roots.

Vegetative spread: Limited.

Longevity: Indefinite.

Reproduction: Spores at any time, peak July–September.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. The gametophytes are colourless, subterranean, very slow growing and depend on an associated fungus which lives in their tissues; they have never been cultivated and rarely have been seen (C. Chambers pers. comm.). [Cultivation unknown (Jones & Clemesha 1981).]

Fire response: Probably killed.

Interaction with other organisms: Epiphytic on *Todea barbara*.

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST; LHI, Qld.

Distribution Sydney area: North from Mt Dromedary, Coast & Mountains.

Select locations: Watagan Mtns, Gosford, McCarrs Ck, Mona Vale (Katandra Bushland Sanctuary), Coalcliff, Rylstone, Blackheath, Wentworth Falls, Robertson.

Habitat

Habitat: Damp rock crevices or on trunks of *Todea barbara*.

Altitude: 0–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent–rare.

Vegetation: Rainforest or sandstone gullies in eucalypt forest.

Substrate: Damp rock crevices or on trunks of *Todea barbara*, fertile sandstone soils. Moisture supply intermittent, fresh.

Exposure: Sheltered situations.

Conservation

Conservation: Conservation status unknown.

Pteris ensiformis**PTERIDACEAE**

Slender Brake

Life history

Growth form: Terrestrial fern with short-creeping rhizome.

Vegetative spread: Limited.

Longevity: Indefinite.

Reproduction: Spores produced in sori on lower surface of frond.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Disturbance is detrimental but once established in cultivation is easy to grow (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalized exotic, native to Queensland.

Botanical subregions: CC*, Qld, Asia, Pacific.

Distribution Sydney area: Naturalized in Sydney district (Harden 1990).

Select locations: (no herbarium specimens)

Habitat

Habitat:

Altitude:

Annual rainfall:

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Conservation status unknown.

Pteris sp. aff. comans**PTERIDACEAE**

Hairy Bracken

Life history**Growth form:** Terrestrial fern with erect tufted rhizome.**Vegetative spread:** Probably not.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing period ? (inadequate material).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Disturbance is detrimental and is much more difficult to cultivate than *P. tremula*; easily raised from spores (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC SC CT; Qld, Vic., Tas., N.Z., Pac.**Distribution Sydney area:** Rare.**Select locations:** Belmore Falls, Minnamurra Falls.**Habitat****Habitat:** In gullies near watercourses, wet places, near creeks or waterfalls.**Altitude:** 0–600 m **Annual rainfall:** 1400 mm**Typical local abundance:** Rare.**Vegetation:** Rainforest or tall open-forest.**Substrate:** Moist ground, basalt and sandstone. No salinity.**Exposure:** Sheltered situations.**Conservation****Conservation:** Regionally rare in Illawarra region (Mills 1988).**Pteris tremula****PTERIDACEAE**

Tender Brake

Life history**Growth form:** Terrestrial fern with erect tufted rhizome; fronds emit an odour resembling urine of tom-cats (Jones 1987).**Vegetative spread:** No.**Longevity:** Short-lived, probably 2–5 years.**Reproduction:** Spores produced in sori on lower surface of frond.

Spore size 34–45 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. Spores retain viability 10–15 years (Jones 1987). Establishes during wet periods and grows quickly. [Easily grown in a variety of habitats, easily raised from spores (Jones & Clemesha 1981).] Naturalized in gardens from spores.**Fire response:** Probably killed.**Interaction with other organisms:** Host to Leaf Nematodes (*Aphelenchoides* spp.) (Jones & Elliot 1986).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT NWS CWS SWP; LHI, Qld, Vic., Tas., N.T., S.A., N.I., N.Z., Fiji.**Distribution Sydney area:** Blue Mtns, also naturalizes in Sydney suburban gardens.**Select locations:** Mt Yengo, Mt Tayan, Mt Wilson, Jenolan, Kanangra, Linden, Wombeyan, Cambewarra.**Habitat****Habitat:** Sheltered places, rocky gullies, rock ledges, creek banks.**Altitude:** 600–1000 m **Annual rainfall:** above 1200 mm**Typical local abundance:** Occasional.**Vegetation:** Rainforest or eucalypt open-forest.**Substrate:** Shale, limestone, basalt. Soil fertile. Water table mostly high, moisture supply intermittent, fresh.**Exposure:** Sheltered situations; mid-light shade.**Conservation****Conservation:** Conservation status unknown. Naturalizes in Sydney suburban gardens and probably in urban bushland.

Pteris umbrosa**PTERIDACEAE**

Jungle Brake

Life history**Growth form:** Terrestrial fern with short-creeping rhizome.**Vegetative spread:** Spreads by rhizome to form colonies.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores at any time except June–August, peak (material inadequate).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT; Qld, Vic.**Distribution Sydney area:** Illawarra, Upper Blue Mtns.**Select locations:** Thirroul, Bulli, Mt Keira, Barrengarry, Minnamurra, Bundanoon, Wentworth Falls.**Habitat****Habitat:** Shaded places, creek beds and flats, usually amongst rocks.**Altitude:** 0–900 m**Annual rainfall:** 1400 mm**Typical local abundance:****Vegetation:** Rainforest.**Substrate:** Often on basalt.**Exposure:****Conservation****Conservation:** Conservation status unknown.**Pteris vittata****PTERIDACEAE**

Chinese Brake

Life history**Growth form:** terrestrial fern with short-creeping rhizome.**Vegetative spread:** Limited spread.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Spores retain viability 10–15 years (Jones 1987). [Very slow-growing in cultivation in southern Australia prefers some lime in the soil mix, resents complete shade, easily raised from spores (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC ?ST; Qld, Vic., N.T., W.A., Asia, Afr., trop.**Distribution Sydney area:** Coastal, rare.**Select locations:** Patonga, Castlecrag, Bellambi.**Habitat****Habitat:** On hillsides, often near streams.**Altitude:** 0–300 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Rare.**Vegetation:****Substrate:** On sandstone, granite or limestone. Naturalized on rock cuttings at Castlecrag.**Exposure:****Conservation****Conservation:** Rare, conservation status unknown.

Salvinia molesta ***SALVINIACEAE****Life history**

Growth form: Free-floating, mat-forming aquatic fern.

Vegetative spread: Spreads vegetatively by fragmentation and can grow from a single node. In warm water, with high nutrient levels and good light it can double its mass in 2 days (Ryan 1982).

Longevity: Indefinite.

Reproduction: Sporocarps borne on pendant branches of submerged, much-divided leaf. Sporocarps sterile as species is of hybrid origin.

Dispersal, establishment & growth: Diaspore: plant fragments dispersed by humans or floods.

Generally grows best in high nutrient levels and water temperatures around 20–30° C, but can survive 10–35° C. Although frost sensitive it can survive these conditions (Sainty & Jacobs 1981). Spread by aquarium trade, local spread by wind, water currents and boat traffic (Australian Weeds 1981).

Fire response: Unlikely to be burnt.

Interaction with other organisms: Mats may interfere with recreation, deplete oxygen levels, shade out submerged plants and foul banks (Australian Weeds 1981).

Distribution

Status/origin: Naturalized exotic. Introduced from S America, probably as an aquarium plant (Ryan 1982).

Botanical subregions: NC CC CWS SWP; Qld, Vic., N.T., S.A., W.A.

Distribution Sydney area: Coastal Sydney, not Tablelands.

Select locations:

Habitat

Habitat: Permanent still or slowly flowing water, or frequently inundated land.

Altitude: 0–300 m?

Annual rainfall: above 700 mm

Typical local abundance: Dominant.

Vegetation: Open water or land frequently inundated.

Substrate: Responds well to high nutrients. Water table permanently high. Tolerates salinity to 20‰ with reduced growth rate (Ryan 1982), but killed by seawater.

Exposure: Full sun.

Conservation

Conservation: Invasive exotic species, taints water storages and seriously affects other aquatic plants. Difficult to eradicate from large areas (Ryan 1982). Proclaimed noxious weed.

Schizaea bifida**SCHIZAEACEAE**

Forked Comb Fern

Life history

Growth form: Terrestrial fern with short-creeping rhizome 5–8 cm deep, fronds clustered, erect, 25–35 cm high, sterile fronds divided 2–20 segments.

Vegetative spread: Limited.

Longevity: Indefinite.

Reproduction: Fertile frond divided 1–2 or 3 times; spores produced in sporangia along both sides of segments pinnately arranged at apex of frond or branches ('combs'). Spores at any time, peak July–August. Spore size 26–45 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind. Dispersal: no special morphology (Westoby *et al.* 1990). Probably no dormancy mechanism. Recruitment mainly after fire (D. Keith pers. comm.). [No record of spore-raising in cultivation, transplanting difficult (Jones & Clemesha 1981).]

Fire response: Resprouts from underground rhizomes.

Interaction with other organisms: Mycorrhizal fungus essential for successful germination and growth (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT; Qld, Vic., Tas., S.A., N.Z., N.Cal.

Distribution Sydney area: Widespread, coast, Blue Mountains.

Select locations: Bucketty, Kariong, Cattai, Terrey Hills, Royal NP, Minnamurra Falls, Mt Wilson, Lawson, Blaxland.

Habitat

Habitat: Rocky hillsides and ridges.

Altitude: 0–1000 m

Annual rainfall: above 900 m

Typical local abundance: Rare.

Vegetation: Eucalypt open-forest, scrub or heath.

Substrate: Sandy soil, often shallow with sandstone rocks. Soil very infertile. Water table mostly low, moisture supply intermittent, fresh.

Exposure: Indifferent to exposure; light shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), probably adequately conserved elsewhere.

Schizaea dichotoma**SCHIZAEACEAE**

Branched Comb Fern

Life history

Growth form: Terrestrial fern, fronds clustered, erect, 20–40 cm high, sterile fronds divided, more than 20 segments.

Vegetative spread: Limited.

Longevity: Indefinite.

Reproduction: Fertile frond divided 3–6 times; spores produced in sporangia along both sides of segments pinnately arranged at apex of frond or branches ('combs'). Spores at any time (limited data). Spore size 21–30 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [No record of spore-raising in cultivation, transplanting difficult (Jones & Clemesha 1981).]

Fire response: Resprouts at ground level or below (Fox 1988).

Interaction with other organisms: Mycorrhizal fungus essential for successful germination and growth (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC; Qld, N.T., W.A., SE Asia, Pac., Madag.

Distribution Sydney area: Coast north from Royal NP — rare.

Select locations: Gosford, Mt Kuringai, Narrabeen, Kurnell, Audley.

Habitat

Habitat: Hillsides with sandstone rocks or rock crevices.

Altitude: 0–100 m

Annual rainfall: above 1200 mm

Typical local abundance: Rare.

Vegetation: Eucalypt open-forest, scrub or heath.

Substrate: Sandy soils from Hawkesbury Sandstone, very infertile. Moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Uncommon, conservation status unknown.

Schizaea fistulosa**SCHIZAEACEAE****Life history**

Growth form: Terrestrial fern with short-creeping rhizome 2–4 cm deep, fronds clustered, erect, simple 10–30 cm long.

Vegetative spread: Limited.

Longevity: Indefinite.

Reproduction: Fertile fronds longer than sterile fronds; spores produced in sporangia along both sides of segments pinnately arranged at apex of frond or branches ('combs'). Spore size 43–77 µm polar dimension (Large & Braggins 1991).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [No record of spore-raising in cultivation, transplanting difficult (Jones & Clemesha 1981).]

Fire response:

Interaction with other organisms: Mycorrhizal fungus essential for successful germination and growth (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: CC ST; Vic., Tas., SA., W.A., N.G., N.Z., Borneo, N.Cal, Chile.

Distribution Sydney area: Only record Chiswick (Five Dock) (1916).

Select locations:

Habitat

Habitat: Various wet habitats, wet peaty soil or on hillocks in bogs.

Altitude: 0–50 m

Annual rainfall: 1200 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Record for Minnamurra Falls but likely to be extinct elsewhere in the area.

Schizaea rupestris**SCHIZAEACEAE****Life history**

Growth form: Terrestrial fern with creeping rhizome, sterile fronds 5–12 cm long.

Vegetative spread: Short-creeping rhizome forms mats.

Longevity: Indefinite.

Reproduction: Fertile fronds 8–20 cm long; spores produced in sporangia along both sides of segments pinnately arranged at apex of frond or branches ('combs'). Spores at any time except June, peak May (limited data).

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism. [No record of spore-raising in cultivation (Jones & Clemesha 1981). Transplanting difficult.]

Fire response:

Interaction with other organisms: Mycorrhizal fungus essential for successful germination and growth (Jones 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST

Distribution Sydney area: Gosford district south to the Budawang Mountains.

Select locations: Gosford, Newport (L.McD.), Narrabeen, Garigal NP (L.McD.), Royal NP, Lawson, Wentworth Falls, Blackheath, Robertson.

Habitat

Habitat: Wet shaded places such as caves or near waterfalls.

Altitude: 0–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent–occasional.

Vegetation: Associated with mosses and ferns, frequently wet eucalypt forest, e.g. with *Livistona australis*.

Substrate: On sandstone rocks. Soil infertile. Water table permanently high, moisture supply continuous, fresh.

Exposure: Deep shade.

Conservation

Conservation: Conservation status unknown.

Selaginella kraussiana ***SELAGINACEAE****Life history****Growth form:** Perennial prostrate growing plant.**Vegetative spread:** Spread by creeping branched stems.**Longevity:** Indefinite.**Reproduction:** Sporangia in cone-like strobili, plants fertile October–November.**Dispersal, establishment & growth:** Diaspore: microspores (male) and megaspores female; commence development while attached to parent plant (Jones 1987). Probably wind or water-dispersed. Megaspore size 370–833 µm, microspore size 30–53 µm polar dimensions (Large & Braggins 1991).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to Africa & the Azores, escape from cultivation.**Botanical subregions:** CC CT SWS; Qld, Vic., Tas., S.A., natural. in Europe & other temperate regions.**Distribution Sydney area:** Widespread.**Select locations:** Mt Wilson*, Albion Park*, Warrimbirra*, RBG Sydney*. Not all Herbarium records available.**Habitat****Habitat:** Cultivated in glasshouses, often established in moist situations such as near ponds and along pathways.**Altitude:** 0–1000 m**Annual rainfall:** 1400 mm**Typical local abundance:****Vegetation:****Substrate:** Water table permanently high, moisture supply continuous, fresh.**Exposure:** Sheltered.**Conservation****Conservation:** Exotic, naturalized locally in wet sites.**Selaginella uliginosa****SELAGINACEAE****Life history****Growth form:** Perennial plant with erect stems 5–38 cm high, simple leaves and subterranean rhizome.**Vegetative spread:** Spread by much branched subterranean rhizome.**Longevity:** Indefinite.**Reproduction:** Sporangia in cone-like strobili. Spores any time except July with peaks in April and August.**Dispersal, establishment & growth:** Diaspore: microspores (male) and megaspores female; commence development while attached to parent plant (Jones 1987). Probably wind-dispersed. Recruitment mainly after fire (D. Keith pers. comm.). In dry seasons the tops of the stems may die.

[Easily grown in pots (Jones & Clemesha 1981).]

Fire response: Resprouts at ground level.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT; LHI, Qld, Vic., Tas., N.T., W.A.**Distribution Sydney area:** Widespread, Coast and Blue Mountains.**Select locations:** Gosford, Narrabeen, Kurnell, Royal NP, Nowra, Blackheath, Wentworth Falls, Belmore Falls, Thirlmere Lakes. Not all Herbarium records available.**Habitat****Habitat:** Ground stratum in damp sandy areas.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Open-forest or heath, also recorded with *Sphagnum* at Robertson.**Substrate:** Deep sand or sandy soils on sandstone, very infertile soil. Perennially moist sites either from seepage and soaks or swampy poorly drained non-saline conditions.**Exposure:** Sheltered. Light–mid shade.**Conservation****Conservation:** Probably adequately conserved.

Cheilanthes austrotenuifolia (C. tenuifolia) SINOPTERIDACEAE

Rock Fern

Life history**Growth form:** Terrestrial fern with short creeping rhizome.**Vegetative spread:** Can spread by creeping rhizomes to form a fresh green 'pasture' on hillsides with soil 10–12 cm deep over rock (Duncan & Isaac 1986).**Longevity:** Indefinite. Perennates during summer by rhizome while fronds die down (Quirk & Chambers 1981).**Reproduction:** Spores produced in sori on lower surface of frond. Spore size 33–50 µm diameter (32 per sporangium), (P. Farrant pers. comm.).**Dispersal, establishment & growth:** Diaspore: spores, dispersed by wind. Spores produced in sori on lower surface of frond. Probably no dormancy mechanism. [Cultivation in pots, not in shade or too humid location. Aerial portion dies back in summer and new fronds grow in autumn, so should not be watered until winter (P. Farrant pers. comm.).] Spores can tolerate dessication and remain viable for long period, germinated 15 months after collection (Quirk & Chambers 1981). Apogamy observed, can develop sporophyte without fertilization in absence of water droplets (Quirk & Chambers 1981).**Fire response:** Probably resprouts.**Interaction with other organisms:** Reports of the fern causing poisoning in sheep and cattle are numerous but mostly seasonal — diarrhoea in sheep, haemorrhages under the skin and internal bleeding in cattle (Auld and Medd 1987). Sheep poisoning worse when plant was dry, in summer; veterinary experiments suggest that young plants not toxic (Hurst 1942).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC CT ST CWS SWS SWP SFWP; Vic., Tas., S.A., W.A.**Distribution Sydney area:** Mittagong area.**Select locations:** Nowra, Mt. Jellore, Goodmans Ford, Wollondilly River (P. Farrant pers. comm.). Not all Herbarium records available.**Habitat****Habitat:** Rocky ground or exposed rocky slopes.**Altitude:** 0–?600 m**Annual rainfall:** 500–600 mm (P. Farrant pers. comm.).**Typical local abundance:****Vegetation:** Open-forest, woodlands and pastures (Auld & Medd). Sometimes growing in clumps mixed with *C. sieberi* (C. Chambers pers. comm.).**Substrate:** Grows in a variety of habitats and seems to need more moisture and deeper soil than *C. sieberi*. Amongst rocks it often grows in crevices or where soil has accumulated around boulders (Duncan & Isaac 1986). Can withstand periods of drought (Quirk & Chambers 1981).**Exposure:** Exposed, full sun.**Conservation****Conservation:** Conservation status unknown.

Cheilanthes distans**SINOPTERIDACEAE**

Bristly Cloak Fern

Life history**Growth form:** Terrestrial fern with short-creeping rhizome.**Vegetative spread:** Short creeping rhizome.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores at any time (coast), August–October (Tablelands); peak August–October. Spore size 43–79 µm diameter, (P. Farrant pers. comm.).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [In cultivation needs low humidity, must not be shaded, does not need a dry rest period like other *Cheilanthes* species (P. Farrant pers. comm.).] Disturbance is detrimental; can be grown in a semi-protected position. Apogamy observed, can develop sporophyte without fertilization in absence of water droplets (Quirk & Chambers 1981).**Fire response:** Probably resprouts.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NW CWS SWS NWP SWP; LHI, Qld, Vic., S.A., W.A., N.I., N.Z., N.Cal.**Distribution Sydney area:** Coastal, Campbelltown to Mulgoa and Lower Blue Mountains.**Select locations:** Watagan Mtns, Peats Ridge, Newport, Kogarah, Menai, Mt Annan, Razorback, Mulgoa, Yerranderie, Jenolan Caves, Hill End, Minnamurra. Pennant Hills, Drummoyne, Nowra, Mosman, Manly Kogarah, Cattai, Wallacia, Calga, Newport, Austinmer (P.F.).**Habitat****Habitat:** Rocky hillsides, rocky crevices in moderately wooded, often mountainous areas, not adapted to extremely arid conditions (P. Farrant pers. comm.).**Altitude:** 0–1000 m**Annual rainfall:** 700–1200 mm**Typical local abundance:** Occasional–rare.**Vegetation:** Woodland or open-forest.**Substrate:** Skeletal soil amongst rocks, shale, basalt, slates, rarely sandstone. Soil fertile–infertile. Water table permanently low, moisture supply intermittent, fresh. Shallow soil pockets in dry rocky hillsides, never in moist constantly humid environments; can withstand periods of drought (Quirk & Chambers 1981).**Exposure:** Indifferent–sheltered; light shade–no shade.**Conservation****Conservation:** Conservation status unknown.

Cheilanthes sieberi subsp. **sieberi**

SINOPTERIDACEAE

Rock Fern

Life history**Growth form:** Terrestrial with short to medium-creeping rhizome.**Vegetative spread:** Can spread up to 5 cm per year.**Longevity:** Indefinite. Perennates during summer by rhizome while fronds die down (Quirk & Chambers 1981).**Reproduction:** Spores produced in sori on lower surface of frond. Spores at any time, peak March, August (Coast), March (Tablelands). Spore size 49–73 µm diameter (16 per sporangium) or 36–52 µm diameter (32 per sporangium), (P. Farrant pers. comm.).**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Able to withstand high temperatures and considerable water stress. During hot weather it often dries off leaving clumps of persistent, stiff brown fronds. (Duncan & Isaac 1986). [Cultivation in pots, not in shade or location too humid. Some or all fronds die down in summer, so should not be watered until winter (P. Farrant pers. comm.).] Apogamy observed, can develop sporophyte without fertilization in absence of water droplets (Quirk & Chambers 1981).**Fire response:** Resprouts.**Interaction with other organisms:** Sometimes growing in clumps mixed with *C. austrotenuifolia* (C. Chambers).**Distribution****Status/origin:** Native.**Botanical subregions:** All NSW divisions; LHI, Qld, Vic., N.T., S.A., W.A., N.I., N.Z., N.Cal.**Distribution Sydney area:** Widespread Coast, Western Sydney, Lower Blue Mtns, west of Great Dividing Range.**Select locations:** Patonga, Newport, Pennant Hills (P.F.), Kurrajong, Castlereagh, Springwood, Mt Annan, Dapto, Cullen Bullen, Jenolan Caves, Hill End, Bowral.**Habitat****Habitat:** Open places with grassland and mountainous areas in rock crevices, moist soil along creek banks in very arid areas (P. Farrant pers. comm.).**Altitude:** 0–1200 m**Annual rainfall:** 700–1200 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Open-forest or woodland with open grassy understorey.**Substrate:** Variable, rocky or heavy clay e.g. Wianamatta Shale, basalt, granite. Soil very fertile, fertile–infertile. Water table mostly low, moisture supply intermittent, fresh. Can withstand periods of drought (Quirk & Chambers 1981).**Exposure:** Exposed–indifferent; shade, none–light.**Conservation****Conservation:** Conservation status unknown.

Pellaea falcata var. falcata**SINOPTERIDACEAE**

Sickle Fern

Life history**Growth form:** Terrestrial fern with short-creeping rhizome.**Vegetative spread:** Spreads by short-creeping rhizome, ? 5–10 cm/year.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond, October–March.

Spore size 30–41 µm (Large & Braggins 1991).

Dispersal, establishment & growth: Dispersal: no special morphology (Westoby *et al.* 1990).

Spores dispersed by wind. Probably no dormancy mechanism. Drought-resistant, has the properties of a resurrection plant, the cell contents of the leaves are able to revive after desiccation (Duncan & Isaac 1986). [Easily grown in cultivation & will grow in full sunlight.]

Fire response:**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS; LHI, Qld, Vic., Tas., N.Z., N.Cal., Asia.**Distribution Sydney area:** Colo area & north-west Sydney, upper Blue Mtns,

Royal NP–Illawarra, widespread.

Select locations: Mt Corricudgy, Wheeny Creek, Mt Wilson, Galston, Waterfall, Mt Kembla, Camden, Cambewarra.**Habitat****Habitat:** Forest floor or occasionally on damp rocks.**Altitude:** 0–1000 m**Annual rainfall:** 700–1400 mm**Typical local abundance:** Frequent.**Vegetation:** Generally eucalypt tall open-forest, occasionally rainforest, or floodplain tall open-forest with *Eucalyptus tereticornis* (Scholer 1974).**Substrate:** Loamy soil, often alluvial or in rocky crevices, derived from sandstone, shale or basalt. Soil fertile. Water table mostly low, moisture supply intermittent; drainage good.**Exposure:** Sheltered situations; mid–light shade.**Conservation****Conservation:** Probably adequate. Vulnerable in Western Sydney (Benson & McDougall 1991).**Pellaea falcata var. nana****SINOPTERIDACEAE****Life history****Growth form:** Terrestrial fern with short creeping rhizome.**Vegetative spread:** Creeping rhizome.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond, at any time.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily grown in cultivation.] Drought-resistant — fronds shrivel and refreshen when moistened (P. Bostock pers. comm.).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT ST; Qld, Tas.**Distribution Sydney area:** Colo area, Upper Blue Mtns, Mt Kembla–Minnamurra.**Select locations:** Glen Davis, Tollagong Range, Mt Wilson, Mt Tomah, Ourimbah, St Helena, Belmore Falls, Fitzroy Falls, Mt Kembla, Minnamurra Falls, Bundanoon.**Habitat****Habitat:** On damp rocks or boulders in rainforest gullies.**Altitude:** 0–1000 m**Annual rainfall:** above 900 mm**Typical local abundance:** Frequent.**Vegetation:** On rainforest floor or rarely in wet eucalypt forest.**Substrate:** On rocks or boulders of sandstone or basalt. Soil fertile. Moisture supply continuous, fresh.**Exposure:** Mid–deep shade.**Conservation****Conservation:** Conservation status unknown.

Pellaea paradoxa**SINOPTERIDACEAE****Life history****Growth form:** Terrestrial fern with medium-creeping rhizome.**Vegetative spread:** Creeping rhizome.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Spores tiny.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. Possibly drought resistant. [Disturbance is detrimental; very slow to re-establish when transplanted (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT ST SWS; Qld, N.Z.**Distribution Sydney area:** Coastal ranges.**Select locations:** Watagan SE, Ourimbah, Gosford, Newport, north of Mt Irvine, reported from Minnamurra but not confirmed (Mills 1988).**Habitat****Habitat:** Rock crevices in rainforest gullies.**Altitude:** 0–600 m**Annual rainfall:** 1200–1400 mm**Typical local abundance:****Vegetation:** Mainly in rainforest but extending to drier sites in rock crevices, cliff faces etc.**Substrate:** Soils from Narrabeen strata, fertile. Drainage good. Moisture supply regular, fresh.**Exposure:** Sheltered situations; mid-deep shade.**Conservation****Conservation:** Regionally rare in Illawarra region (Mills 1988), conservation status unknown.**Christella dentata****THELYPTERIDACEAE****Life history****Growth form:** Terrestrial fern with short-creeping rhizome; fronds emit an acrid, musky odour (Jones 1987).**Vegetative spread:****Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Material inadequate to indicate sporing times.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very easily grown and adaptable to a variety of situations; fast growing; frost hardy in southern Victoria (Jones & Clemesha 1981).] Occasional colonizer in suburban gardens.

Spore size 24–35 µm polar dimension (Large & Braggins 1991).

Fire response:**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC; LHI, Qld, S.A., W.A., Pac., trop. & subtrop regions of Asia & Africa.**Distribution Sydney area:** Coast & lower Blue Mtns, north from Cambewarra, not common.**Select locations:** Gosford, Gladesville, Cronulla, Douglas Park, Cambewarra, Springwood, Mulgoa.**Habitat****Habitat:** Forms tussocks along stream banks.**Altitude:** 0–400 m**Annual rainfall:** 1000–1200 mm**Typical local abundance:** Rare.**Vegetation:** Rainforest margins and in eucalypt open-forest, also *Casuarina glauca* forest.**Substrate:** Creek banks — on sandstone, infertile soil. Moisture supply continuous, fresh.**Exposure:** Sheltered situations; mid shade.**Conservation****Conservation:** Conservation status unknown.

Christella hispidula**THELYPTERIDACEAE****Life history****Growth form:** Terrestrial fern with erect or short-creeping rhizome.**Vegetative spread:** Limited.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Very easily grown, fast growing, frost tender (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC; Qld, trop.**Distribution Sydney area:** Rare in NSW, recorded from lower Hunter Valley (Harden 1990). Lane Cove Valley (1992), possibly garden escape.**Select locations:** Lane Cove (Van Klaphake pers. comm. 1992)**Habitat****Habitat:** Stream banks.**Altitude:** 0–100 m **Annual rainfall:** above 1200 mm**Typical local abundance:** About 40 plants (Lane Cove).**Vegetation:** Open-forest.**Substrate:** Hawkesbury Sandstone.**Exposure:****Conservation****Conservation:** Conservation status unknown.**Cyclosorus interruptus****THELYPTERIDACEAE****Life history****Growth form:** Terrestrial fern with long-creeping rhizome.**Vegetative spread:** Long-creeping rhizome.**Longevity:** Indefinite.**Reproduction:** Spores produced in sori on lower surface of frond. Sporing peak probably March.**Dispersal, establishment & growth:** Diaspore: spores dispersed by wind, probably no dormancy mechanism. [Easily cultivated, frost hardy, takes full sun in a wet spot (Jones & Clemesha 1981).]**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC; Qld, N.T., W.A., N.Z., trop.**Distribution Sydney area:** Coast north from Royal NP, rare.**Select locations:** Swansea, Woy Woy, Kogarah, Kurnell, Audley.**Habitat****Habitat:** Forms large clumps in freshwater swamps.**Altitude:** 0–50 m **Annual rainfall:** 1200 mm**Typical local abundance:** Rare.**Vegetation:** Freshwater swamps.**Substrate:** Sandy loam, infertile soil.**Exposure:****Conservation****Conservation:** Rare, only 6 collections, 5 old, Audley southern limit. Conservation status unknown.

Vittaria elongata

VITTARIACEAE

Life history

Growth form: Pendent, epiphytic fern with creeping rhizome.

Vegetative spread: Limited.

Longevity:

Reproduction: Spores produced in sori on lower surface of frond.

Dispersal, establishment & growth: Diaspore: spores dispersed by wind, probably no dormancy mechanism.

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld, Malesia, Pacific.

Distribution Sydney area: Watagan Mountains.

Select locations: Watagan Mountains (1979), the only record.

Habitat

Habitat: Wet tall eucalypt open-forest.

Altitude: 0–500 m

Annual rainfall: above 1400 mm

Typical local abundance:

Vegetation: With other epiphytes e.g. *Hymenophyllum cupressiforme*, *Davallia pyxidata*.

Substrate: Sandstone boulders.

Exposure:

Conservation

Conservation: Rare in CC, Watagan Mountains southern limit, conservation status unknown.

Cycads

Macrozamia communis**ZAMIACEAE****Life history**

Growth form: Palm-like plant; trunk subterranean or on shallow soil 1–2 m high, spirally arranged, leaves 0.7–2 m long.

Vegetative spread: No vegetative spread.

Longevity: More than 60 years; estimated up to 120 years at Bateman's Bay (Cribb 1981).

Primary juvenile period: Possibly 10–20 years.

Reproduction: Male and female cones on separate plants, 20–45 cm long. Pollen dispersed by wind. Seed 3–4.5 cm long, with a fleshy, scarlet coat. Released at maturity.

Dispersal, establishment & growth: Diaspore: seed, dispersed short distance; no dormancy. Seeds germinate slowly without treatment. Often scattered on ground surface, no soil-stored seedbank. Seedlings slow growing, 1 leaf per year as juvenile; faster growth when older (B. Briggs pers. comm.). Seedlings may be clustered around female plant. Seedlings with a tuberous stem and apogeotropic, coralloid roots contain nitrogen-fixing, symbiotic blue-green algae *Anabaena* (Beadle 1972).

Fire response: Resprouts from above ground level.

Interaction with other organisms: Aborigines leached toxin (azoxyglycosides) from seeds before using for food (Beadle 1972). Leaves toxic to stock, causing serious motor-neurone disease (Hurst 1942, [most reports refer to *M. communis* (K. Hill pers. comm.)]).

Early settlers used pulu from base of leaves to fill cushions, mattresses and upholstery (Maiden 1975 & Cribb 1981). Commercial extraction of starch from stems in 1920s, recent investigation for production of power alcohol (Cribb 1981).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CWS; Qld.

Distribution Sydney area: Coast and adjacent ranges.

Select locations: Norah Head, Woy Woy, Palm Beach, Bondi 1876 (Cribb 1981), Kurnell, Colo Heights, Cambewarra, Nowra, Caoura–Tallong.

Habitat

Habitat: Well drained sandy soils.

Altitude: 0–400 m **Annual rainfall:** above 900 mm

Typical local abundance: Frequent.

Vegetation: Sclerophyll woodland and forest.

Substrate: Infertile sandy soil. Water table permanently low, moisture supply intermittent, fresh.

Exposure: Sheltered, light shade.

Conservation

Conservation: Probably not at risk.

Macrozamia pauli-guilielmi subsp. **flexuosa** ZAMIACEAE**Life history**

Growth form: Palm-like plant; stem mostly subterranean, leaves 40–110 cm long, spirally arranged.

Vegetative spread: No vegetative spread.

Longevity: More than 60 years.

Primary juvenile period:

Reproduction: Male cones 8–25 cm long, female cones 10–25 cm long, on separate plants. Pollen dispersed by wind. Seeds c. 3 cm long, orange-scarlet. Released at maturity.

Dispersal, establishment & growth: Diaspore: seed, probably no dormancy mechanism or soil-stored seedbank. Seedlings with a tuberous stem and apogeotropic, coralloid roots containing nitrogen-fixing, symbiotic blue-green algae *Anabaena* (Beadle 1972).

Fire response: Probably resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC.

Distribution Sydney area: Morisset (old record only).

Select locations: Morisset (1899).

Habitat

Habitat: Coastal ranges.

Altitude: 50 m

Annual rainfall: 1200 mm

Typical local abundance:

Vegetation: Sclerophyll forest.

Substrate:

Exposure:

Conservation

Conservation: Southern limit Morisset though not known if it still occurs there, conservation status unknown.

Macrozamia secunda

ZAMIACEAE

Life history

Growth form: Palm-like plant; stem mostly subterranean; leaves 60–80 cm long, spirally arranged.

Vegetative spread: No vegetative spread.

Longevity: More than 60 years.

Primary juvenile period:

Reproduction: Male cones 15–20 cm long, female cones 15–25 cm long, on separate plants. Pollen dispersed by wind. Fruiting peak April (limited data). Seeds 2–3.5 cm long, scarlet; probably released at maturity.

Dispersal, establishment & growth: Diaspore: seed. Probably no dormancy mechanism or soil-stored seedbank. Seedlings with a tuberous stem and apogeotropic, coralloid roots containing nitrogen-fixing, symbiotic blue-green algae *Anabaena* (Beadle 1972).

Fire response: Probably resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CT CWS.

Distribution Sydney area: North west of area, Rylstone–Kedumba.

Select locations: Rylstone, Olinda, Capertee, Ben Bullen, Kedumba Valley.

Habitat

Habitat: Ridges and hillsides.

Altitude: 400–800 m

Annual rainfall: less than 900 mm

Typical local abundance: Occasional–rare, though sometimes locally frequent.

Vegetation: Dry eucalypt open-forest, Ironbark–Stringybark.

Substrate: Sandy or stony country, gravelly clay. Soil very infertile. Water table permanently low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Conservation status unknown.

Macrozamia spiralis**ZAMIACEAE****Life history**

Growth form: Palm-like plant; trunk usually subterranean, leaves 60–80 cm long, spirally arranged. A variable species, larger with $\pm$ glaucous leaves in Lower Blue Mountains.

Vegetative spread: No vegetative spread.

Longevity: More than 60 years.

Primary juvenile period: Possibly 10–20 years.

Reproduction: Male cones 15–20 cm long, female cones 12–20 cm long, on separate plants.

Pollen dispersed by wind. Fruiting peak April–May (limited data). Seeds 2.5–3 cm long, orange–scarlet, fleshy coat; released at maturity.

Dispersal, establishment & growth: Diaspore: seed. Probably no dormancy mechanism or soil-stored seedbank. Seedlings with a tuberous stem and apogeotropic, coralloid roots containing nitrogen-fixing, symbiotic blue-green algae *Anabaena* (Beadle 1972).

Fire response: Resprouts at ground level in response to fire.

Interaction with other organisms: Aborigines used seeds for food after washing and roasting; old newspaper reports that the seeds were also used by early settlers for production of starch and arrowroot (Hurst 1942).

Distribution

Status/origin: Native.

Botanical subregions: CC CWS.

Distribution Sydney area: Mainly western Sydney.

Select locations: Colo River, Castlereagh SF, Maroota, Llandillo, Mulgoa, Picnic Point, Leumeah, Glen Davis.

Habitat

Habitat: Hillsides and gentle slopes.

Altitude: 0–300 m **Annual rainfall:** 700–800 mm

Typical local abundance: Occasional.

Vegetation: Dry eucalypt open-forest e.g. woodland with *Angophora bakeri* and *Eucalyptus fibrosa*.

Substrate: Clay, sandy clay soils from Tertiary alluvium or shale/sandstone transition, dry stony soils, very infertile. Water table mostly low, moisture supply intermittent, fresh.

Exposure: Indifferent to exposure.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991) e.g. Castlereagh State Forest, conservation status elsewhere unknown.

Conifers

Callitris endlicheri

CUPRESSACEAE

Black Cypress Pine

Life history

Growth form: Tree, sometimes glaucous, with spreading branches.

Vegetative spread: No vegetative spread.

Longevity:

Primary juvenile period:

Reproduction: Male and female cones. Pollen dispersed by wind. Female cones 15–20 mm diameter, shed periodically. Seeds winged.

Dispersal, establishment & growth: Diaspore: winged seed, wind-dispersed.

Probably no dormancy mechanism. No soil-stored seedbank.

100% mortality when stem cut to ground level (Leigh & Holgate 1979).

Fire response: Killed by fire (100 % scorch) (A.M. Gill pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic.

Distribution Sydney area: Blue Mountains, widespread.

Select locations: Howes Valley, Darkes Forest, Warragamba, Hill End, Glowworm Tunnel (Newnes Plateau), Mt Victoria, Abercrombie Falls, Berrima, Tallowa Dam area.

Habitat

Habitat: Stony hills or ridges, sandstone outcrops.

Altitude: 0–1100 m

Annual rainfall: 800–1200 mm

Typical local abundance: Frequent–occasional.

Vegetation: Dry sclerophyll forest, heath and mallee.

Substrate: Sandy soils, gravelly clay, sandstone outcrops, slate, well-drained. Soil infertile.

Water table permanently low with intermittent moisture supply, fresh.

Exposure: Exposed.

Conservation

Conservation: Probably adequately conserved.

Callitris muelleri

CUPRESSACEAE

Life history

Growth form: Small tree or shrub to 6 m, with erect branches.

Vegetative spread: No vegetative spread.

Longevity: Medium, probably 25–50 years.

Primary juvenile period:

Reproduction: Male and female cones. Pollen dispersed by wind. Female cones 20–30 mm diameter, retained on tree.

Dispersal, establishment & growth: Diaspore: winged seeds, no dormancy mechanism. Seeds dispersed following death of branch or fire. Seeds germinate without treatment. Seed supply retained on plant, no soil-stored seedbank. Seedling recruitment mainly after fire.

Fire response: Plant killed by fire, seedlings 27 cm high, 3–4 yrs after fire (David Keith, pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC CT.

Distribution Sydney area: South from Mt Coricudgy, widespread.

Select locations: Gosford, Ku-ring-gai Chase, Thornleigh, Mosman, Menai, Mt Kembla, Mt Coricudgy, Newnes, Mt Victoria, Wentworth Falls, Bundanoon.

Habitat

Habitat: Rocky places, especially sandstone escarpments in the coastal ranges.

Altitude: 0–1100 m

Annual rainfall: above 1200 mm

Typical local abundance: Occasional but may be locally common.

Vegetation: Heath-scrub, forest.

Substrate: Sandy soil from sandstone, rocky exposed sites. Low nutrient soils.

Permanently low water table with intermittent moisture supply. Non-saline.

Exposure: Exposed, no shade.

Conservation

Conservation: Northern limit Mt Coricudgy. Probably adequately conserved.

Callitris rhomboidea**CUPRESSACEAE**

Port Jackson Pine

Life history**Growth form:** Tree or shrub with spreading branches.**Vegetative spread:** No vegetative spread.**Longevity:** Possibly 50 years.**Primary juvenile period:** Possibly 5–7 years.**Reproduction:** Male and female cones. Pollen dispersed by wind. Female cones 20 mm diameter, retained on tree (Ken Hill pers. comm.).**Dispersal, establishment & growth:** Diaspore: winged seeds. Seed dispersal following death of branch, or fire. Probably no dormancy mechanism. Seed supply retained on plant, no soil-stored seedbank.**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT; Qld, Vic., Tas., S.A.**Distribution Sydney area:** Coast and tablelands, widespread but not common.**Select locations:** Berowra, Mosman, Sylvania, Heathcote, Maldon, Yanderra, Coricudgy Creek, Glow-worm Tunnel (near Lithgow), Newnes Junction.**Habitat****Habitat:** Rocky ridges or steep slopes.**Altitude:** 0–1100 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Woodland, heathland and mallee.**Substrate:** Sandy soils on rocky ridges or steep slopes, sandstone. Water table permanently low, moisture supply intermittent, fresh.**Exposure:** Exposed, no shade.**Conservation****Conservation:** Widespread but not common, probably adequately conserved.

Pinus pinaster ***PINACEAE**

Cluster Pine

Life history**Growth form:** Tall tree.**Vegetative spread:** No vegetative spread.**Longevity:** More than 60 years.**Primary juvenile period:****Reproduction:** Male and female cones. Pollen dispersed by wind.**Dispersal, establishment & growth:** Diaspore: winged seed, 3.5 cm long. Probably no dormancy mechanism. Probably no soil-stored seedbank.**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Exotic, introduced from Mediterranean region as an ornamental.**Botanical subregions:** CC CT; Vic.**Distribution Sydney area:** Sydney suburbs.**Select locations:** Near Kariong (Ken Hill pers. comm.).**Habitat****Habitat:** Often planted as windbreaks and as ornamental trees.**Altitude:** 0–200 m**Annual rainfall:** above 1200 mm**Typical local abundance:****Vegetation:****Substrate:** Found in sandy soil (Simpfendorfer 1975). Not in clay soil — will grow in sea sand (Dallimore & Jackson 1966). Salt tolerant.**Exposure:** Can stand severe coastal exposure (Simpfendorfer 1975).**Conservation****Conservation:** Occasionally naturalised in the area.**Pinus radiata *****PINACEAE**

Radiata Pine, Monterey Pine

Life history**Growth form:** Large tree — can exceed 50 m in good conditions.**Vegetative spread:** No vegetative spread.**Longevity:** More than 60 years.**Primary juvenile period:** 5–10 years.**Reproduction:** Male and female cones. Pollen dispersed by wind. Seeds 2.5 cm long.**Dispersal, establishment & growth:** Diaspore: winged seed 2.5 cm long, probably wind-dispersed. Probably no dormancy mechanism or soil-stored seedbank. Grows rapidly when young. Widely planted, major plantation species in cooler regions. Commercial importance in Australia, S Africa & N.Z. — rapid growth makes it suitable as a short rotation crop (Dallimore & Jackson 1966). Comprises 70% of the Australian coniferous plantation resource (McKinnel *et al.* 1991).**Fire response:** Killed by fire.**Interaction with other organisms:** Foodplant of moth caterpillar *Digglea australasiae* (Coupar 1992). Young trees browsed by wallabies, possums, native rats and rabbits; most widespread fungal disease of Radiata Pine is *Diplodea pinea* (McKinnel *et al.* 1991).**Distribution****Status/origin:** Exotic, native to California. Introduced to Australia in 1859 (Simpfendorfer 1975).**Botanical subregions:** NT, CT; Vic.**Distribution Sydney area:** Mainly tablelands.**Select locations:** Mittagong, Blackheath, Bilpin, Jenolan, Oberon.**Habitat****Habitat:** Locally naturalized in cooler districts.**Altitude:** 0–1200 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Pine plantations and adjacent areas (Harden 1990).**Substrate:** Well-drained, poor to moderately fertile soil; can withstand summer droughts (Simpfendorfer 1975).**Exposure:** Can withstand severe coastal exposure in suitable soil (Simpfendorfer 1975).**Conservation****Conservation:** Naturalised in cooler districts particularly on margins of plantations.

Microstrobos fitzgeraldii**PODOCARPACEAE****Life history**

Growth form: Ascending or erect shrub mostly less than 1 m tall.

Vegetative spread:

Longevity:

Primary juvenile period:

Reproduction: Male and female cones. Pollen dispersed by wind. Female cones 3 mm long, seeds small.

Dispersal, establishment & growth: Diaspore: seed, probably water or wind dispersed, probably no dormancy mechanism. Probably no soil-stored seedbank. Difficult in cultivation, needs constant misting.

Fire response: Intolerant of fire (Leigh & Briggs 1992). Wet sites probably serve as fire refugia.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CT

Distribution Sydney area: Upper Blue Mountains. The total population of about 300 plants is distributed in six locations along 8 km of cliffline between Wentworth Falls and Katoomba in the Blue Mountains (Smith 1981).

Select locations: Wentworth Falls, Gordon Falls, Leura Falls, Katoomba Falls, Bonnie Doon Falls.

Habitat

Habitat: On wet rocks within the spray of waterfalls or on ledges or in caves near waterfalls; southerly aspect.

Altitude: above 900 m

Annual rainfall: above 1400 mm

Typical local abundance: Occasional. Smith (1981) recorded total population of 203 plants from 6 localities.

Vegetation: With ferns & lithophytes.

Substrate: Wet sandstone rocks within the spray of waterfalls or on ledges or in caves near waterfalls. Soil infertile. Water table permanently high, moisture supply continuous, fresh.

Exposure: Sheltered situations. Southerly aspect.

Conservation

Conservation: Very restricted local endemic, coded 2VCi (Leigh & Briggs 1992). Most populations are reserved within Blue Mountains National Park. The largest population at Jamieson Creek, Wentworth Falls is being adversely affected by pollution in the catchment from sewage, sediment and nutrients from gardens (Leigh & Briggs 1992). Plants from Wentworth Falls (National Pass Level) carried extensive dead leaves. Creek disturbance and pollution may lead to foliage damage (Smith 1981).

Podocarpus elatus

PODOCARPACEAE

Plum Pine, Brown Pine

Life history

Growth form: Medium to large tree with brown bark that is often fissured and scaly, dioecious or rarely monoecious.

Vegetative spread: No vegetative spread.

Longevity: More than 60 years.

Primary juvenile period:

Reproduction: Male cones catkin-like to 3 cm long, female cones consist of 2–4 scales each bearing an ovule. Pollen dispersed by wind. Fruiting receptacle fleshy, edible but not appetising, blue-black, to 20 mm diameter bearing single seed 10 mm long. Shed at maturity, Jan–July, peak March.

Dispersal, establishment & growth: Diaspore: seed, probably bird-dispersed. Probably no dormancy mechanism and no soil-stored seedbank.

Fire response:

Interaction with other organisms: Softwood timber suitable for indoor use, resistant to termites and marine borers but seldom used owing to scarcity; excellent ornamental and shelter tree (Anderson 1956). Tested negative for anti-tumour activity (Collins *et al.* 1990).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC; Qld.

Distribution Sydney area: Coastal, north from Beecroft Peninsula.

Select locations: Gosford, Church Point, Shellharbour, Kiama, Whispering Gallery.

Habitat

Habitat: Coastal.

Altitude: 0–200 m

Annual rainfall: above 1200 mm

Typical local abundance: Occasional.

Vegetation: Coastal rainforest or scrub.

Substrate: Sandy soils, infertile.

Exposure:

Conservation

Conservation: Conservation adequacy unknown.

Podocarpus spinulosus

PODOCARPACEAE

Life history

Growth form: Shrub or small tree with narrow-linear leaves usually 2–6 cm long.

Vegetative spread:

Longevity: Indefinite.

Primary juvenile period:

Reproduction: Male cones 5 mm long in clusters, female cones solitary in leaf axils. Pollen dispersed by wind. Fruiting receptacle blue-black, fleshy, bearing 1–2 seeds, 8–12 mm long. Shed at maturity, August–January, peak October.

Dispersal, establishment & growth: Diaspore: seed, probably bird-dispersed. Probably no dormancy mechanism or soil-stored seedbank.

Fire response: Resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC; Qld.

Distribution Sydney area: Widespread.

Select locations: Patonga, Dee Why, Pennant Hills, Garigal NP (L.McD.), Moorebank, Macquarie Fields, Thirlmere Lakes, Kenthurst, Glen Davis.

Habitat

Habitat: Sheltered coastal sites and gullies on the adjacent ranges.

Altitude: 0–500 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent–occasional.

Vegetation: Eucalypt open-forest.

Substrate: Deep sandy soil, creek flats, Hawkesbury Sandstone. Soil infertile. Water table mostly low, fresh.

Exposure: Sheltered situations.

Conservation

Conservation: Probably adequately conserved.

Flowering Plants: dicotyledon families Acanthaceae to Asclepiadaceae

Brunoniella australis

ACANTHACEAE

Blue Trumpet

Life history

Growth form: Perennial herb 2–15 cm high with clusters of tuberous roots joined by underground rhizome. Leaf surface with cystoliths — mineral concentration usually of calcium carbonate.
Vegetative spread: Vegetative spread by underground rhizome, probably forming localised patches.
Longevity: Indefinite.
Primary juvenile period:
Flowers: March and September–November. Two different flower types may occur on the same plant, one large and presumably insect-pollinated, one smaller and presumably self-pollinated (Barker 1986).
Fruit/seed: Fruit: capsule 10–16 mm long with 8–12 seeds, matures November–December.
Dispersal, establishment & growth:
Fire response: Resprouts at ground level and may flower within a month of fire, probably dependent on fire to remove competition from taller species.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC NWS CWS NWP; Qld, N.T.
Distribution Sydney area: Cumberland Plain and Lower Blue Mountains — widespread.
Select locations: Richmond, Prospect, Glenfield, Camden, Douglas Park (southern limit), Valley Heights.

Habitat

Habitat: Eucalypt woodland with grassy understorey.
Altitude: 0–600 mm **Annual rainfall:** 700–1000 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt woodland with grassy understorey — commonly with *Eucalyptus moluccana*, *Eucalyptus tereticornis*, *Eucalyptus crebra* and *Bursaria spinosa*.
Substrate: Clay soils from Wianamatta Shale. Fertile soil. Water table permanently low, moisture supply intermittent, fresh. Cystoliths possibly response to calcium in soil.
Exposure: Indifferent to exposure, light shade or none.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991), Douglas Park (southern limit).

Brunoniella pumilio

ACANTHACEAE

Dwarf Blue Trumpet

Life history

Growth form: Small sprawling perennial herb to 10 cm high. Leaf surface sometimes has cystoliths — mineral concentration usually of calcium carbonate.
Vegetative spread:
Longevity: 5–20 years (D. Keith pers. comm.).
Primary juvenile period:
Flowers: March, November.
Fruit/seed: Fruit: capsule 12–17 mm long with 8–12 seeds, matures November.
Dispersal, establishment & growth: Recruitment mainly after fire (D. Keith pers. comm.).
Fire response: Resprouts at ground level or below.
 Secondary juvenile period 1 year (D. Keith pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC; Vic.
Distribution Sydney area: Coast and Putty area.
Select locations: Gibba Swamp, Putty Road, Woy Woy, Pennant Hills, Oatley (1892), Casula.

Habitat

Habitat: Woodland.
Altitude: 0–400 m **Annual rainfall:** 1000–1200 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt woodland e.g. with *Angophora bakeri* or *Melaleuca* scrub.
Substrate: Sandstone. Sandy loam soils, infertile. Water table permanently low, fresh.
Exposure:

Conservation

Conservation: Conservation status unknown.

Pseuderanthemum variabile**ACANTHACEAE**

Pastel Flower

Life history**Growth form:** Perennial herb with creeping rhizome and erect stems.**Vegetative spread:** Creeping rhizome.**Longevity:** Indefinite.**Primary juvenile period:****Flowers:** October–April, peak February.**Fruit/seed:** Capsule 10–15 mm long with 1–4 seeds, each 2–4 mm long.**Dispersal, establishment & growth:** Diaspore: seed, no special morphology (Westoby *et al.* 1990).

Soil-stored seedbank (Floyd 1966).

Fire response: Resprouts. Secondary juvenile period less than 1 year.**Interaction with other organisms:** Frequently eaten by cattle (W.H. Blakely, comment on specimen collected at Gordon in 1914).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC; Qld, N.T.**Distribution Sydney area:** Coast and Lower Blue Mountains — widespread.**Select locations:** St Albans, Wamberal, Hornsby, Doonside, Liverpool, Camden, Glenbrook, Garie, Berry, Minnamurra Falls.**Habitat****Habitat:** Sheltered forest.**Altitude:** 0–300 m**Annual rainfall:** 700–1400 mm**Typical local abundance:** Frequent.**Vegetation:** Open-forest to tall open-forest, occasional rainforest e.g. *Eucalyptus saligna*–*Eucalyptus pilularis* tall open-forest, *Eucalyptus amplifolia* open-forest.**Substrate:** Fertile–very fertile clay soil from Wianamatta Shale, basalt. Water table permanently low, moisture supply intermittent, fresh.**Exposure:** Sheltered, in mid shade.**Conservation****Conservation:** Conserved in Western Sydney (Benson & McDougall 1991) and probably adequately conserved elsewhere.**Thunbergia alata *****ACANTHACEAE**

Black-eyed Susan

Life history**Growth form:** Vigorous, woody, stoloniferous vine.**Vegetative spread:** Possibly.**Longevity:****Primary juvenile period:****Flowers:** August–March.**Fruit/seed:** Fruit: woody capsule with seed 4 mm diameter, mature May (limited data).**Dispersal, establishment & growth:** Attractive fleshy edible fruits or seeds dispersed by animals; vegetative reproducer, dispersed by gravity or water (Anon 1991).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, introduced from S Africa. Garden escape in various places.**Botanical subregions:** NC CC; Qld.**Distribution Sydney area:** Sydney and Cumberland Plain, Illawarra.**Select locations:** Bardwell Park (1946 earliest collection), Epping, Waterfall, Casula, Kurrajong, Shellharbour.**Habitat****Habitat:** Disturbed vegetation and vacant land.**Altitude:** 0–300 m**Annual rainfall:** 800–1200 mm**Typical local abundance:** Occasional.**Vegetation:** Remnant dry rainforest and sheltered woodland.**Substrate:** Clay fertile soils from Wianamatta Shale. Water table mostly low, moisture supply intermittent, fresh.**Exposure:** Sheltered situations in light shade.**Conservation****Conservation:** Minor weed of bushland, no specific threat.

Acer negundo ***ACERACEAE**

Box Elder

Life history**Growth form:** Small deciduous, usually dioecious tree to 8 m high.**Vegetative spread:** No.**Longevity:** Up to 50 years.**Primary juvenile period:****Flowers:** Late August–early September (Price 1963).**Fruit/seed:** Winged fruit (samara) 3–4 cm long, mature January.**Dispersal, establishment & growth:** Diaspore: seed. Wind-dispersed locally, seed probably short-lived with no dormancy mechanism; also water-dispersed (Carr *et al.* 1992). Seedlings to 10 cm high common along Hawkesbury River edge in October–November.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to America. Garden escape probably from Camden area originally.**Botanical subregions:** NC CC NT ST.**Distribution Sydney area:** Naturalised along Nepean River, Menangle–Penrith, widely cultivated.**Select locations:** Camden (1959), Cobbitty, Bents Basin.**Habitat****Habitat:** Banks of Nepean River, wetlands.**Altitude:** 0–300 m **Annual rainfall:** 700–900 mm**Typical local abundance:** Frequent.**Vegetation:** Degraded riparian eucalypt forest e.g. with *Eucalyptus elata*, *Eucalyptus viminalis*, *Casuarina cunninghamiana*.**Substrate:** Deep sandy alluvial deposits. Soil fertile. Water table mostly high, moisture supply intermittent, fresh.**Exposure:** Sheltered situations; mid shade.**Conservation****Conservation:** Invades remnant native vegetation along Nepean River but may provide bank protection where other vegetation is absent. Seedlings along Hawkesbury River in 1992, as far down as Windsor.**Acer pseudoplatanus *****ACERACEAE**

Sycamore Maple

Life history**Growth form:** Deciduous, monoecious tree to 30 m high.**Vegetative spread:****Longevity:** Up to 50 years.**Primary juvenile period:****Flowers:** November.**Fruit/seed:** Winged fruit (samara) 3.5–5.5 cm long, matures January–April.**Dispersal, establishment & growth:** Diaspore: seed. Wind-dispersed locally.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised. Introduced from Europe.**Botanical subregions:** CT; Vic., Tas., S.A.**Distribution Sydney area:** Jenolan Caves.**Select locations:** Jenolan Caves.**Habitat****Habitat:** On hillside and in gullies, mainly SE aspect.**Altitude:** 800 m **Annual rainfall:** 1000 mm**Typical local abundance:** Dominant.**Vegetation:** Moist eucalypt forest.**Substrate:** Limestone and basalt. Soil very fertile–fertile. Water table mostly high, moisture supply intermittent, fresh.**Exposure:** Sheltered situations; mid–light shade.**Conservation****Conservation:** Thoroughly naturalised over about 25 ha at Jenolan Caves, completely taking over from existing vegetation. Thought to have originated from a few trees planted in 1960 (J. Dellow, Herbarium note).

Aptenia cordifolia ***AIZOACEAE**

Heartleaf Ice Plant

Life history**Growth form:** Spreading or scrambling perennial herb forming mats to 1 m diameter.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** December–February, June–August.**Fruit/seed:** Fruit: a hygroscopic capsule 9–12 mm long with many seeds.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to S Africa.**Botanical subregions:** NC CC SC CWS; S.A.**Distribution Sydney area:** Coast and Nepean River.**Select locations:** Grose Vale, Long Bay, La Perouse, Douglas Park, Nepean River, Wollongong (1912).**Habitat****Habitat:** Rocky hillsides, road cuttings, soil dumps and fill.**Altitude:** 0–120 m **Annual rainfall:** above 800 mm**Typical local abundance:** Occasional.**Vegetation:** Near rainforest, weedy sites.**Substrate:** Rocky hillsides on sandstone, roadside soil dumps and fill. Infertile soil.**Exposure:****Conservation****Conservation:** Impact unknown.**Carpobrotus edulis *****AIZOACEAE**

Hottentot Fig

Life history**Growth form:** Prostrate perennial with stems to 2 m long.**Vegetative spread:** Spreads locally by rooting at nodes of long trailing stems.**Longevity:** Indefinite.**Primary juvenile period:****Flowers:** April, August–September.**Fruit/seed:** Subglobose, succulent, berry-like fruit 2.5–3 cm diam., yellowish, dehiscent, with numerous seeds embedded in mucilage.**Dispersal, establishment & growth:** Diaspore: fragmented pieces of stem, seed? Bird, vegetative and possibly animal dispersal (Carr *et al.* 1992).**Fire response:** Unlikely to burn because of succulent nature.**Interaction with other organisms:** Fruit edible to humans.**Distribution****Status/origin:** Exotic, native to S Africa.**Botanical subregions:** CC SC; Vic., Tas., S.A., W.A.**Distribution Sydney area:** Coastline.**Select locations:** Cooper Park, Long Bay, Lady Robinsons Beach (1913), Five Islands.**Habitat****Habitat:** Exposed rocky foreshores and ridges, coastal sand dunes.**Altitude:** 0–20 m **Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Coastal heath, ground stratum.**Substrate:** Sand over sandstone. Infertile soil. Water table mostly low, moisture supply intermittent.**Exposure:** Exposed; no shade.**Conservation****Conservation:** Impact unknown.

Carpobrotus glaucescens**AIZOACEAE**

Pigface

Life history

Growth form: Prostrate perennial with fleshy triquetrous leaves and rooting at nodes of long trailing stems.

Vegetative spread: Spreads locally by rooting at nodes of long trailing stems.

Longevity: Short-lived, less than 5 years (Clarke 1989).

Primary juvenile period:

Flowers: June–January.

Fruit/seed: Succulent, berry-like fruit 2–3 cm long with numerous seeds embedded in mucilage.

Dispersal, establishment & growth: Diaspore: probably seed, dispersed by animals (Clarke 1989), also vegetative distance dispersal by fragmented pieces of stem.

Fire response: Probably rarely burnt, but unlikely to burn because of succulent nature.

Interaction with other organisms: Fruit edible by humans.

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC; Qld, Vic.

Distribution Sydney area: Coastline.

Select locations: Norah Head, Bondi, Cape Solander, Lake Illawarra.

Habitat

Habitat: Coastal sand dunes and sandstone cliffs.

Altitude: 0–50 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Dune and seacliff scrub. At the upper limit of saltmarsh, probably above all but storm tides. In open sandy communities (Adam 1981).

Substrate: Coastal sand dunes and sandstone cliffs. Infertile soil. Water table mostly low, moisture supply intermittent, brackish. Intolerant of waterlogging (Clarke 1989).

Exposure: Exposed, no shade. Seedlings shade intolerant, sun tolerant (Clarke 1989).

Conservation

Conservation: Conservation status unknown.

Galenia pubescens * (*G. secunda*)**AIZOACEAE****Life history**

Growth form: Prostrate or decumbent perennial herb.

Vegetative spread: No.

Longevity: Perennial.

Primary juvenile period:

Flowers: December.

Fruit/seed: Fruit dry capsule 3 mm long. Seed 1 mm long, shiny black.

Dispersal, establishment & growth:

Fire response: Does not burn easily — can be killed if sufficient fuel available.

Interaction with other organisms: Recorded as toxic to stock.

Distribution

Status/origin: Naturalised exotic, native to S Africa.

Botanical subregions: NC CC SC CWS SWP NFWP; Vic., S.A.

Distribution Sydney area: Coast.

Select locations: Only records for area — Botany Bay (north shore) (1977), Windang (1969).

Habitat

Habitat: Grassy areas near shoreline.

Altitude: 0–20 m

Annual rainfall: above 1200 mm

Typical local abundance: Occasional.

Vegetation: Grassy disturbed sites.

Substrate: Earth, rubble. Water table permanently low, moisture supply intermittent.

Exposure:

Conservation

Conservation: Recent exotic introduction, not very common but often locally abundant around mining areas (Harden 1990).

Lampranthus multiradiatus *

AIZOACEAE

Life history**Growth form:** Decumbent or ± erect perennial shrub.**Vegetative spread:** Spreads by rooting at nodes.**Longevity:** Indefinite.**Primary juvenile period:****Flowers:****Fruit/seed:** Fruit: a capsule with many seeds.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to S Africa.**Botanical subregions:** CC; S.A., W.A.**Distribution Sydney area:****Select locations:** Cape Banks (1961).**Habitat****Habitat:****Altitude:** 0–20 m**Annual rainfall:** above 1200 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Mostly cultivated, rarely naturalised.**Lampranthus tegens ***

AIZOACEAE

Life history**Growth form:** Spreading prostrate shrub rooting at the nodes.**Vegetative spread:** Local spreading by rooting at nodes. Distance dispersal possible by broken fragments taking root.**Longevity:****Primary juvenile period:****Flowers:** September–December, peak September.**Fruit/seed:** Fruit: capsule with many seeds.**Dispersal, establishment & growth:** Diaspore: seeds, stem fragments? Possibly water-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** This species was described from Australia and though possibly originating from South Africa, attempts to equate it with known African species have not been successful (Jacobs, see Harden 1990). There would appear to be a possible case that it is an Australian species and in any case it should be protected here as the only known populations of the species (Paul Adam pers. comm.).**Botanical subregions:** CC; Vic.**Distribution Sydney area:** Parramatta & Lane Cove Rivers.**Select locations:** Ermington, Homebush Bay, Concord (1904), Lane Cove River.**Habitat****Habitat:** Mudflats and other sites submerged by very high tides.**Altitude:** 0–2 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Saltmarsh with *Suaeda australis* & *Sarcocornia quinqueflora* or *Juncus kraussii* rushland.**Substrate:** Mudflats and fill causeways, receiving infrequent tidal inundation. Soil fertile, water table mostly high, moisture supply intermittent, saline.**Exposure:** No shade.**Conservation****Conservation:** Rare saltmarsh species needing protection.

Macarthuria neocambrica**AIZOACEAE****Life history****Growth form:** Diffuse herb to 20 cm high.**Vegetative spread:** No vegetative spread.**Longevity:****Primary juvenile period:****Flowers:** May, September (few records).**Fruit/seed:** Fruit: globose capsule 2 cm long. Seeds 1.5 mm long, black, with small white aril.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC; Qld, ?N.T.**Distribution Sydney area:** Coast south to Wybung Head.**Select locations:** Southern limit, Munmorah SRA (only record for the area).**Habitat****Habitat:** Coastal headlands.**Altitude:** 0–50 m**Annual rainfall:** 1200–1400 mm**Typical local abundance:** Occasional.**Vegetation:** Heath of *Banksia aemula* and *Xanthorrhoea resinosa*.**Substrate:** Pleistocene bleached white sand. Very infertile soil. Water table mostly low, moisture supply intermittent, fresh.**Exposure:** No shade.**Conservation****Conservation:** Southern limit, Munmorah SRA.**Mollugo verticillata****AIZOACEAE****Life history****Growth form:** Diffuse annual herb to 30 cm high.**Vegetative spread:** No.**Longevity:** Very short, less than 2 yrs.**Primary juvenile period:****Flowers:** February–March.**Fruit/seed:** Capsule 3–4 cm long, with numerous brown seeds.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC; Qld.**Distribution Sydney area:** Penrith area, Normanhurst, rare.**Select locations:** Yarramundi Crossing, Emu Plains, Normanhurst.**Habitat****Habitat:** Disturbed sites, edge of river, along railway track.**Altitude:** 0–50 m**Annual rainfall:** 800–1200 mm**Typical local abundance:** Frequent.**Vegetation:** Disturbed sites, possibly originally along the Hawkesbury-Nepean River.**Substrate:** Sandy soil, infertile. Water table mostly low, moisture supply intermittent, fresh.**Exposure:****Conservation****Conservation:** In NSW only found in CC, rare, not conserved in any reserve.

Vulnerable.

Sesuvium portulacastrum**AIZOACEAE****Life history**

Growth form: Succulent prostrate herb with stems to 1 m rooting at the nodes.
Vegetative spread: Rooting at nodes, and probably dispersed vegetatively by pieces of stem.
Longevity: Annual or short-lived perennial.
Primary juvenile period:
Flowers:
Fruit/seed: Fruit: capsule 8 mm long. Seeds 1.5 mm long, smooth black.
Dispersal, establishment & growth: Diaspore: seed, stem fragments.
Fire response: In habitat unlikely to be burnt.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC; LHI, Qld, N.T., W.A.
Distribution Sydney area: Coast north of Tuggerah Lakes.
Select locations: Tuggerah Lakes, entrance to Lake Macquarie.

Habitat

Habitat: Foreshore, and intertidal zone mudflats, foredunes, strand lines.
Altitude: 0–5 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent.
Vegetation: Mudflat herbs.
Substrate: Sand or mud. Soil fertile or infertile, saline. Water table mostly high, plants partly in water at high tide.
Exposure: Exposed, no shade.

Conservation

Conservation: Conservation status unknown.

Tetragonia nigrescens ***AIZOACEAE****Life history**

Growth form: Slightly succulent, annual or perennial herb with underground tuber.
Vegetative spread:
Longevity: Annual or perennial, probably short-lived.
Primary juvenile period:
Flowers: March.
Fruit/seed: Fruit: capsule enclosed in floral tube which becomes bony on drying, matures November.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S Africa.
Botanical subregions: NC CC.
Distribution Sydney area: Coastline, Sydney.
Select locations: Watsons Bay (1919), Maroubra Bay (1916, 1933).

Habitat

Habitat: Coastal foredune.
Altitude: 0–20 m **Annual rainfall:** 1200 mm
Typical local abundance:
Vegetation: Dune sand, ground stratum.
Substrate: Infertile soil.
Exposure:

Conservation

Conservation: Rare coastline exotic.

Tetragonia tetragonoides**AIZOACEAE**

New Zealand Spinach

Life history**Growth form:** Prostrate spreading annual or short-lived perennial herb.**Vegetative spread:****Longevity:** Annual or short-lived perennial.**Primary juvenile period:****Flowers:** Yellow, at any time.**Fruit/seed:** Subglobose woody fruit, 10–12 mm diameter, winged. Seeds numerous, light brown.**Dispersal, establishment & growth:** Diaspore: fruit, enclosed in fruiting calyx (?).**Fire response:** Vigorous growth ?from seed, after high intensity fire at Killarney Hts, spread 1.5 m in 6.5 months — after 2 years plant still alive but in poor condition (L.McD.).**Interaction with other organisms:** Green plants poisonous if eaten (Everist 1974). High levels of soluble oxalate recorded associated with sheep death (Cunningham *et al.* 1981), though rarely eaten by stock (Auld & Medd 1987). Livestock prefer to leave it until the stems and leaves are dry and presumably low in oxalate; used by early explorers as a cooked 'Spinach-like' vegetable (Everist 1974).**Status/origin:** Native.**Distribution****Botanical subregions:** NC CC SC NWS CWS NWP SWP NFWP SFWP; LHI, Qld, Vic., Tas., S.A., W.A., N.Z.**Distribution Sydney area:** Sea coasts and margins of salt marshes.**Select locations:** Neilsen Park, Concord, Tempe, Botany Bay, Tempe.**Habitat****Habitat:** Sea coasts and margins of salt marshes.**Altitude:** 0–10 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Occasional.**Vegetation:** Upper margins of saltmarsh, or sea cliffs e.g. with *Westringia fruticosa*, estuarine strand lines.**Substrate:** Sands, silts or in rocky crevices at base of sea cliffs. Water table mostly high, ?saline.**Exposure:****Conservation****Conservation:** Probably adequately conserved.**Trianthema portulacastrum *****AIZOACEAE**

Giant Pigweed

Life history**Growth form:** Procumbent or ascending annual herb.**Vegetative spread:** No.**Longevity:** Annual.**Primary juvenile period:** Less than 1 year.**Flowers:****Fruit/seed:** Fruit: capsule with 3–12 seeds.**Dispersal, establishment & growth:** Diaspore: seed. Forms dense mats in some areas as a spring and summer weed (Auld & Medd 1987).**Fire response:****Interaction with other organisms:** Poisoning of hungry stock recorded but the plant is not palatable and rarely eaten (Everist 1974).**Distribution****Status/origin:** Exotic, native to Indonesia, America, Africa.**Botanical subregions:** CC NWS NWP; Qld, W.A., N.T.**Distribution Sydney area:** Flemington.**Select locations:** Only Sydney record Flemington Saleyards (1969).**Habitat****Habitat:** Damp places, often near rivers.**Altitude:** 0–50 m**Annual rainfall:** 800 mm**Typical local abundance:** Frequent.**Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Rare in area, probably no longer growing at Flemington Saleyards.

Weed of cultivation from tropical regions.

Trianthema triquetra

AIZOACEAE

Life history**Growth form:** Prostrate or ascending herb with stems 20–60 cm long.**Vegetative spread:****Longevity:** Annual.**Primary juvenile period:****Flowers:** March–April.**Fruit/seed:** Fruit: capsule with 2 black seeds.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:** Killed.**Interaction with other organisms:** Probably introduced to CC with stock. Suspected of poisoning stock; contains saponin (Hurst 1942), and sometimes HCN (Everist 1974).**Distribution****Status/origin:** Naturalised in CC. Probably introduced from Western NSW with stock.**Botanical subregions:** CC* CWS NWP NFWP; Qld, N.T., S.A., W.A., pantrop.**Distribution Sydney area:** Flemington Saleyards.**Select locations:** Recorded for Flemington Saleyards only.**Habitat****Habitat:** Saleyards.**Altitude:** 0–5 m**Annual rainfall:** 1000 mm**Typical local abundance:** Occasional.**Vegetation:** Probably with introduced weeds.**Substrate:** Sandy and/or saline soils. Moisture supply intermittent, fresh or saline.**Exposure:****Conservation****Conservation:** As a result of re-development of Flemington Saleyards probably no longer growing in CC.**Zaleya galericulata subsp. australis**

AIZOACEAE

Hogweed

Life history**Growth form:** Annual or perennial herb.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** March.**Fruit/seed:** Capsule 5 mm long. Seeds 2 mm diameter, black.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised in CC. Probably introduced from Western NSW.**Botanical subregions:** CC* NWS CWS SWS NWP SWP NFWP; Qld.**Distribution Sydney area:** Flemington Saleyards.**Select locations:** Flemington Saleyards only.**Habitat****Habitat:** Saleyards.**Altitude:** 0–50 m**Annual rainfall:** 1000 mm**Typical local abundance:****Vegetation:** Probably with introduced weeds.**Substrate:****Exposure:****Conservation****Conservation:** As a result of re-development of Flemington Saleyards probably no longer growing in CC.

Achyranthes aspera

AMARANTHACEAE

Chaff Flower

Life history**Growth form:** Erect or spreading herbaceous annual or biennial to 1 m high.**Vegetative spread:** No.**Longevity:** Annual or biennial.**Primary juvenile period:** 1 year.**Flowers:****Fruit/seed:** Fruit cylindrical, 1-seeded.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC; LHI, Qld, N.T., W.A., trop.**Distribution Sydney area:** Coast.**Select locations:** Darlinghurst (1927). (Limited data, specimens on loan.)**Habitat****Habitat:** Waste ground.**Altitude:****Annual rainfall:****Typical local abundance:****Vegetation:****Substrate:** Sandstone.**Exposure:****Conservation****Conservation:** CC is the southern limit.**Alternanthera angustifolia**

AMARANTHACEAE

Life history**Growth form:** Prostrate to ascending ephemeral herb.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** Probably insect pollinated (Cook 1990).**Fruit/seed:** Fruit indehiscent, compressed, 1-seeded.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC NWP; N.T., S.A.**Distribution Sydney area:****Select locations:** (Limited data, specimens on loan)**Habitat****Habitat:****Altitude:****Annual rainfall:****Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Conservation status unknown.

Alternanthera denticulata**AMARANTHACEAE**

Lesser Joyweed

Life history**Growth form:** Prostrate or decumbent annual herb rooting at nodes.**Vegetative spread:** Local limited spread.**Longevity:** Very short, less than 1 year.**Primary juvenile period:****Flowers:** November–December (Price 1963). Probably insect pollinated (Cook 1990).**Fruit/seed:** Indehiscent, 1-seeded fruit, maturing December–August (limited data).**Dispersal, establishment & growth:** Diaspore: fruit, also fragmented stem nodes provide propagules for vegetative dispersal, e.g. by floods. Growth rate slow.**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** All divisions except NFWP; all States.**Distribution Sydney area:** Western Sydney, Bathurst area.**Select locations:** Dora Creek, Shane Park, Annangrove, Carlingford, Agnes Banks, Mount Annan, Mount Pleasant (Bathurst).**Habitat****Habitat:** Margins of wetlands, fresh or occasionally saline.**Altitude:** 0–800 m**Annual rainfall:** 600–1200 mm**Typical local abundance:** Occasional.**Vegetation:** Ground stratum in grassy woodland or herbland e.g. with *Eucalyptus tereticornis*. Sometimes a weed of pastures and waste places.**Substrate:** Sandy river banks, alluvial flats and clay areas. Fertile soil. Water table mostly high, moisture supply intermittent. Brackish or fresh.**Exposure:** No shade.**Conservation****Conservation:** Conserved in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.**Alternanthera nana****AMARANTHACEAE**

Hairy Joyweed

Life history**Growth form:** Herb with prostrate or ascending stems.**Vegetative spread:** Yes.**Longevity:****Primary juvenile period:****Flowers:** Probably insect pollinated (Cook 1990).**Fruit/seed:** Fruit indehiscent, compressed, 1-seeded.**Dispersal, establishment & growth:** Growth rate slow.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC NT CT ST NWS SWS; Qld.**Distribution Sydney area:** Western Sydney.**Select locations:** Agnes Banks, Mt Annan (J. Howell 1992).**Habitat****Habitat:** Wetland.**Altitude:****Annual rainfall:****Typical local abundance:****Vegetation:** Grassy woodland e.g. with *Eucalyptus moluccana*, *Eucalyptus tereticornis*.**Substrate:****Exposure:****Conservation****Conservation:** Conservation status unknown.

Alternanthera philoxeroides ***AMARANTHACEAE**

Alligator Weed

Life history

Growth form: Stoloniferous, aquatic, semi-aquatic or terrestrial perennial herb forming dense floating or rooted mats.

Vegetative spread: Stolons 10 m long, rooting at nodes and forming mats.

Longevity: Indefinite.

Primary juvenile period:

Flowers: February, probably insect-pollinated (Cook 1990).

Fruit/seed: Fruit indehiscent, 1-seeded. Seeds not viable (Griffiths 1989).

Dispersal, establishment & growth: Diaspore: pieces of stem dispersed by water.

Grows prolifically in summer.

Fire response:

Interaction with other organisms: Alligator Weed Flea-beetle *Agasicles hygrophila* introduced in 1976 and reduced floating mats on Georges River but not effective on river banks (Griffiths 1989). Larvae of moth *Vogtia malloi* liberated in 1977 and soon became established but introduction of beetle *Agasicles hygrophila* achieved more spectacular results (Common 1990).

Distribution

Status/origin: South America, thought to have been accidentally introduced to Australia in ships' ballast released in Newcastle Harbour and Botany Bay about 1944 (Griffiths 1989).

Botanical subregions: NC CC SWS.

Distribution Sydney area: Coastal lakes and rivers.

Select locations: Budgewoi Lake (1988), Narara (1988), Woy Woy Creek (1988), Georges River, Glenfield (1983), Georges Hall (1982), Moorebank (1988), Camden (1988).

Habitat

Habitat: On stream banks and in shallow water.

Altitude: 0–50 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent–dominant.

Vegetation:

Substrate: Alluvial sand and silt, above high tide mark (at Budgewoi Lake). Fresh–saline, rafts can survive in water up to 30% as salty as sea water (Griffiths 1989).

Exposure: No shade.

Conservation

Conservation: May crowd out other species, proclaimed noxious throughout NSW.

Alternanthera pungens * (A. repens)

AMARANTHACEAE

Khaki Weed

Life history

Growth form: Prostrate ephemeral or perennial herb with deep taproot; stems softly hairy to 60 cm long.

Vegetative spread: Prostrate trailing stems rooting at nodes enables plant to form mats. Spread by cultivation from pieces of taproot or stem.

Longevity: Deep woody taproot capable of producing new aerial growth annually.

Primary juvenile period:

Flowers: Spring–summer. February, probably insect-pollinated (Cook 1990).

Fruit/seed: Fruit indehiscent, 1-seeded, surrounding bracts forming a burr-like structure. Seeds c. 1.5 mm diam, round (Parsons 1973). Prolific seeder (Smith 1983).

Dispersal, establishment & growth: Diaspore: burr, dispersed by animals and on clothes and rubber tyres. Seeds germinate in spring, deep taproot and creeping stems are produced during late spring and summer when flowers and seeds develop, aerial growth dies in autumn and new growth is produced from the crown again in spring (Parsons 1973).

Fire response:

Interaction with other organisms: Sharply pointed bracts of the flowers make the plant objectionable in recreation areas (Parsons 1981).

Distribution

Status/origin: Exotic, native to Central and South America; first recorded in NSW 1898 (Parsons 1981), further introductions from South Africa during or after the Boer War (Smith 1983).

Possible spread through contaminated fodder used for horses (Parsons 1981).

Botanical subregions: NC CC NT NWS CWS SWS NWP SWP; Qld.

Distribution Sydney area: Western Sydney.

Select locations: Flemington Saleyards (1969), Penrith (1969), Doonside (1984), Bents Basin (1983).

Habitat

Habitat: Roadsides and wasteland. Readily colonises disturbed ground.

Altitude: 0–100 m **Annual rainfall:** above 700 mm

Typical local abundance: Rare.

Vegetation: With grasses and weeds e.g. *Cirsium vulgare*, *Senecio madagascariensis*.

Substrate: Sandy or clayey soil, probably from Wianamatta Shale.

Able to establish on wide range of soil types (Parsons 1973).

Exposure: Full sun.

Conservation

Conservation: Rare in Sydney area, mainly in drier parts of the State.

Amaranthus albus *

AMARANTHACEAE

Tumbleweed

Life history

Growth form: Annual herb to 1 m high.

Vegetative spread: No.

Longevity: Less than 1 year.

Primary juvenile period: Less than 1 year.

Flowers:

Fruit/seed: Membranous fruit with spiny bracts, mature February–April.

Dispersal, establishment & growth: Diaspore: probably fruit, also mature plants may break off at ground level and tumble across open ground (Auld & Medd 1987).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, introduced from Europe.

Botanical subregions: CC CT ST CWS SWS SWP NFWP.

Distribution Sydney area: Sydney suburbs.

Select locations: Botanic Gardens, Summer Hill (1899), Flemington, Richmond (1975), Casula, Campbelltown, Blayney.

Habitat

Habitat: Roadsides, railways, disturbed sites.

Altitude: 0–1000 mm **Annual rainfall:** above 600 mm

Typical local abundance: Rare.

Vegetation: Probably with other weeds of disturbed sites.

Substrate: Earthworks.

Exposure:

Conservation

Conservation: An uncommon weed of disturbed sites.

Amaranthus cruentus ***AMARANTHACEAE**

Redshank

Life history**Growth form:** Erect annual herb, often more than 1 m high.**Vegetative spread:** No.**Longevity:** Less than 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** May.**Fruit/seed:** Membranous fruit, 3 mm long, maturing August; contains numerous, small, brown, disc-shaped, shiny seeds (Everist 1974).**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:** Poisonous to hungry stock (Everist 1974).**Distribution****Status/origin:** Exotic, introduced from America or Asia.

Possibly a contaminant of bird seed (Harden 1990).

Botanical subregions: CC SWS.**Distribution Sydney area:** Sydney suburbs.**Select locations:** Summer Hill (1970–71) only record.**Habitat****Habitat:** Spontaneous in garden.**Altitude:** 0–100 m**Annual rainfall:** 1000 mm**Typical local abundance:****Vegetation:** Cultivated exotics.**Substrate:** Garden soil.**Exposure:****Conservation****Conservation:** Uncommon weed of closely settled areas (Harden 1990).**Amaranthus deflexus *****AMARANTHACEAE**

Spreading Amaranth

Life history**Growth form:** Prostrate to scrambling perennial herb.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** February.**Fruit/seed:** Membranous fruit 1 mm long, maturing February. Seeds glossy.**Dispersal, establishment & growth:** Diaspore: fruit/seed, possibly animal-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, introduced from Europe.**Botanical subregions:** CC ST.**Distribution Sydney area:****Select locations:** Cowan (1921), Epping Railway Platform (1982), Flemington Saleyards (1968).**Habitat****Habitat:** Disturbed sites possibly associated with railways and livestock.**Altitude:** 0–200 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Occasional.**Vegetation:****Substrate:** Cracks in paving stones (at Flemington).**Exposure:****Conservation****Conservation:** Uncommon weed.

Amaranthus hybridus ***AMARANTHACEAE**

Slim Amaranth

Life history**Growth form:** Erect or slightly spreading annual herb to 1.5 m high.**Vegetative spread:** No.**Longevity:** Less than 1 year.**Primary juvenile period:****Flowers:** Late January–April (Price 1963).**Fruit/seed:** Membranous fruit 2 mm long, mature April, August.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic species of cosmopolitan origin.**Botanical subregions:** NC CC SC ST SWP; Qld, Vic., S.A.**Distribution Sydney area:** Widespread.**Select locations:** Wollombi, Richmond, Wahroonga, Ermington, Royal Botanic Gardens (1903), Cooks River (1911), Summer Hill, lower Kowmung River.**Habitat****Habitat:** Weed of cultivation and disturbed areas e.g. along railway lines, vacant blocks, river flats, saleyards.**Altitude:** 0–300 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent.**Vegetation:****Substrate:** Cultivated soil, sandy soil, fill material.**Exposure:****Conservation****Conservation:** Weed of cultivation, not invasive of bushland.**Amaranthus lividus *****AMARANTHACEAE****Life history****Growth form:** Procumbent to erect perennial herb to 80 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** January–March.**Fruit/seed:** Membranous fruit, 2 mm long, maturing January–March.**Dispersal, establishment & growth:** Dispersal: fruit/seed, possibly animal-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic species occurring in Africa, America, Asia, Europe.**Botanical subregions:** NC CC.**Distribution Sydney area:** Sydney suburbs.**Select locations:** Royal Botanic Gardens (1902, 1922, 1936, 1975), Paddington, Waterloo, Flemington Saleyards.**Habitat****Habitat:** Suburban streets, vacant land.**Altitude:** 0–200 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Rare.**Vegetation:****Substrate:** Disturbed sites, probably sandy soil.**Exposure:****Conservation****Conservation:** Uncommon weed of suburban areas.

Amaranthus macrocarpus var. macrocarpus AMARANTHACEAE

Dwarf Amaranth

Life history**Growth form:** Erect annual to 30 cm high.**Vegetative spread:** No.**Longevity:** Less than 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:****Fruit/seed:** Fruit indehiscent, spongy, black or brown, matures March–April.**Dispersal, establishment & growth:** Diaspore: fruit/seed, possibly animal-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Probably introduced from western NSW with livestock.**Botanical subregions:** NC* CC* NWS CWS NWP SWP; Qld.**Distribution Sydney area:** Few records.**Select locations:** Royal Botanic Gardens (1914), Flemington Saleyards (1969),

Glenfield Research Station (1974), the only records.

Habitat**Habitat:** Sites with high livestock usage.**Altitude:** 0–200 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent–uncommon.**Vegetation:****Substrate:** Recorded near manure heap.**Exposure:****Conservation****Conservation:** Conservation status unknown.**Amaranthus macrocarpus var. pallidus** AMARANTHACEAE

Dwarf Amaranth

Life history**Growth form:** Erect annual to 30 cm high.**Vegetative spread:** No.**Longevity:** Less than 1 year.**Primary juvenile period:****Flowers:****Fruit/seed:** Fruit indehiscent, spongy.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC NWS CWS NWP NFWP; Qld, Eur.**Distribution Sydney area:****Select locations:** Royal Botanic Gardens (1898), Cowan (1921).**Habitat****Habitat:** Reported as a weed in pots (Royal Botanic Gardens), and along railway line.**Altitude:** 0–100 m**Annual rainfall:** above 1200 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Possibly introduced sporadically from other parts of the State.

No recent collections. Conservation status unknown.

Amaranthus powellii *

AMARANTHACEAE

Powell's Amaranth

Life history**Growth form:** Erect annual herb to 1 m high.**Vegetative spread:** No.**Longevity:** Less than 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** February–April.**Fruit/seed:** Membranous fruit 3–5 mm long, matures February–June.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Tropics.**Botanical subregions:** NC CC SC CT ST NWS; Vic., Tas., S.A.**Distribution Sydney area:** Widespread.**Select locations:** Windsor, Dundas, Hornsby, Flemington Saleyards, Camden, Kiama, Bathurst, Blayney, Mt Wilson, Jenolan Caves (1900).**Habitat****Habitat:** Disturbed sites and cultivated areas.**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent.**Vegetation:****Substrate:** Probably clay soils.**Exposure:****Conservation****Conservation:** Impact unknown.**Amaranthus quitensis ***

AMARANTHACEAE

South American Amaranth

Life history**Growth form:** Erect annual herb often more than 1 m high.**Vegetative spread:** No.**Longevity:** Less than 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:****Fruit/seed:** Membranous fruit 1.5–2.5 mm long, matures March–June.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic from South America.**Botanical subregions:** NC CC NWS.**Distribution Sydney area:** Flemington (only).**Select locations:** Flemington Saleyards (1969, 1970, 1972).**Habitat****Habitat:** Saleyards.**Altitude:** 0–100 m**Annual rainfall:** 900 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Weed of summer crops in Lower Hunter Valley (Auld & Medd 1987).

Amaranthus retroflexus ***AMARANTHACEAE**

Redroot Amaranth

Life history**Growth form:** Erect annual herb to 1 m high.**Vegetative spread:** No.**Longevity:** Annual.**Primary juvenile period:** Less than 1 year.**Flowers:** February–March.**Fruit/seed:** Membranous fruit 3 mm long, maturing April.**Dispersal, establishment & growth:** Diaspore: fruit/seed, possibly animal-dispersed.

Flowers at various sizes according to conditions.

Fire response:**Interaction with other organisms:****Distribution****Status/origin:** Exotic from America.**Botanical subregions:** CC CT ST SWS NWP SWP; S.A.**Distribution Sydney area:** Few localities.**Select locations:** Cheltenham (1949), Flemington Saleyards, Wolgan Valley, Glanmire.**Habitat****Habitat:** Weed of roadsides and cultivation.**Altitude:** 0–800 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:****Substrate:** Cultivated paddocks, gardens, saleyards.**Exposure:****Conservation****Conservation:****Amaranthus spinosus *****AMARANTHACEAE**

Needle Burr

Life history**Growth form:** Erect annual herb to 1 m high.**Vegetative spread:** No.**Longevity:** Less than 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** October–November (Price 1963).**Fruit/seed:** Membranous fruit 2 mm long, maturing August.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, introduced from tropics.**Botanical subregions:** NC CC; Qld.**Distribution Sydney area:** Lane Cove to Hawkesbury River.**Select locations:** Peats Ferry (1887), Hawkesbury River (1912), Hornsby (1915), Lane Cove River (1889).**Habitat****Habitat:** Weed.**Altitude:** 0–200 m**Annual rainfall:** above 1200 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Weed — all records pre 1915, probably uncommon.

Amaranthus viridus *

AMARANTHACEAE

Green Amaranth

Life history

Growth form: Spreading annual herb to 40 cm high.

Vegetative spread:

Longevity: Less than 1 year.

Primary juvenile period: Less than 1 year.

Flowers: January–April (Price 1963), peak February–March.

Fruit/seed: Membranous fruit 2 mm long, matures March, May, August.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms: Crushed and used as a healing poultice in Asia (Low 1990).

Occasionally cooked and eaten as spinach; killed fowls in Brisbane area (Everist 1974).

Distribution

Status/origin: Exotic, origin uncertain, now widespread throughout warmer parts of the world (Auld & Medd 1987).

Botanical subregions: CC SC CWS NWP SWP; LHI, Qld, N.T., S.A., trop.

Distribution Sydney area: Sydney suburbs.

Select locations: Hornsby, Cheltenham, Balgowlah, RBG (1914, 1936, 1972, 1975, 1983), Museum of Applied Arts & Sciences (1895), Ashfield, Mascot, Richmond.

Habitat

Habitat: Roadsides, embankments, gardens.

Altitude: 0–200 m

Annual rainfall: above 600 mm

Typical local abundance: Frequent–occasional.

Vegetation: Probably with other weeds of disturbed sites.

Substrate: Garden soils, clay.

Exposure:

Conservation

Conservation: Common garden weed.

Deeringia amaranthoides

AMARANTHACEAE

Life history

Growth form: Climber to 4 m high or sometimes a small shrub.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: December–May.

Fruit/seed: Fruit: red berry in December–August, 4–5 mm diameter, with many black shiny seeds.

Dispersal, establishment & growth: Diaspore: berry, possibly bird-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT CWS; Qld, Asia.

Distribution Sydney area: Widespread.

Select locations: Capertee River, Bilpin (Green Scrub), Coxs River, Razorback, Werong Beach, Cambewarra, Upper Kangaroo Valley.

Habitat

Habitat: Hillsides near creeks.

Altitude: 0–700 m

Annual rainfall: above 600 mm

Typical local abundance: Frequent.

Vegetation: Rainforest and dry scrub.

Substrate: Basalt, quartzite, shaley sandstone. Fertile soil. Water table mostly low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Regionally rare in Illawarra region (Mills 1988).

Froelichia gracilis ***AMARANTHACEAE****Life history****Growth form:** Erect to ascending herb to 25 cm high with woody taproot.**Vegetative spread:** Probably not.**Longevity:****Primary juvenile period:****Flowers:** Feb.**Fruit/seed:** Fruit hard and burr-like, 1-seeded, matures February.**Dispersal, establishment & growth:** Diaspore: probably fruit.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, naturalised, introduced from America.**Botanical subregions:** CC.**Distribution Sydney area:** Localised.**Select locations:** Agnes Banks (1982), Kanimbla Valley (1982).**Habitat****Habitat:** Riverbank.**Altitude:** 0–700 m**Annual rainfall:** 700–900 mm**Typical local abundance:** Frequent.**Vegetation:****Substrate:** Floodplain soil, probably sandy alluvium, fertile.**Exposure:****Conservation****Conservation:** Recently recorded as naturalised, potential unknown.**Gomphrena celosioides *****AMARANTHACEAE**

Gomphrena Weed

Life history**Growth form:** Prostrate to ascending herb with thick fleshy taproot.**Vegetative spread:****Longevity:** Annual or possibly short-lived perennial.**Primary juvenile period:****Flowers:****Fruit/seed:** Fruit compressed indehiscent, 1-seeded.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:** Poisonous to horses (Everist 1974).**Distribution****Status/origin:** Exotic, native to America.**Botanical subregions:** NC CC SC NWS CWS SWS NWP SWP; Qld.**Distribution Sydney area:** Western Sydney.**Select locations:** Flemington (1969), Doonside, Campbelltown.**Habitat****Habitat:** Roadsides, cultivated or disturbed areas.**Altitude:** 0–100 m**Annual rainfall:** 700–1000 mm**Typical local abundance:****Vegetation:** Weeds of disturbance.**Substrate:** Clay soils from Wianamatta Shale.**Exposure:** Full sun.**Conservation****Conservation:** Widespread weed (Harden 1990).

Guilleminia densa *

AMARANTHACEAE

Small Matweed

Life history

Growth form: Perennial, prostrate hairy herb with swollen woody rootstock.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: February–March.

Fruit/seed: Fruit: a membranous, dehiscent bladder-like sac with one seed, 0.6 mm long.

Matures February–March.

Dispersal, establishment & growth: Diaspore: probably seed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to America.

Botanical subregions: NC CC NWS; Qld.

Distribution Sydney area: Coastal.

Select locations: Putty Beach (1988), only record for area.

Habitat

Habitat: Mown disturbed sites, roadsides, caravan parks (Harden 1990).

Altitude: 0–50 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Mown grassland.

Substrate: Sandy soils.

Exposure:

Conservation

Conservation: Recent introduction to the area.

Nyssanthes diffusa

AMARANTHACEAE

Barbwire Weed

Life history

Growth form: Erect to spreading annual or biennial herb.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period:

Flowers:

Fruit/seed: Fruit membranous, indehiscent, enclosed in persistent spiny perianth.

Matures October–March.

Dispersal, establishment & growth: Diaspore: probably fruit.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT NWS CWS.

Distribution Sydney area: Western Sydney and Illawarra.

Select locations: Grose Vale, Cobbitty, Razorback, Kowmung River, Mt Annan, Albion Park, Berry.

Habitat

Habitat: Dry rainforest on rocky sites.

Altitude: 0–200 m

Annual rainfall: 600–1200 mm

Typical local abundance: Frequent.

Vegetation: Dry rainforest.

Substrate: Shaley sandstone (in Wianamatta group), diatremes. Soil fertile. Water table mostly low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).

Nyssanthes erecta**AMARANTHACEAE****Life history****Growth form:** Erect to spreading herb.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** February–April.**Fruit/seed:** Fruit membranous, indehiscent, enclosed in persistent spiny perianth. Matures December.**Dispersal, establishment & growth:** Diaspore: probably fruit.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC CWS; Qld.**Distribution Sydney area:** Western Sydney, Kiama district.**Select locations:** Berkshire Park, Minnamurra Creek, Nowra.**Habitat****Habitat:** Along creeks, sometimes disturbed areas.**Altitude:** 0–50 m **Annual rainfall:** 800–1300 mm**Typical local abundance:** Frequent.**Vegetation:** Creekside vegetation e.g. with *Angophora floribunda*, *Acacia parramattensis*.**Substrate:** Alluvial, fertile soil.**Exposure:****Conservation****Conservation:** Probably not well conserved.**Prunus cerasifera *****AMYGDALACEAE**

Cherry Plum

Life history**Growth form:** Slender deciduous tree.**Vegetative spread:** No.**Longevity:** 25–60 years.**Primary juvenile period:****Flowers:** August.**Fruit/seed:** Fruit fleshy 2–3 cm diameter, cherry-like, red or yellow, flesh juicy and sweet.

Shed at maturity, November–January.

Dispersal, establishment & growth: Diaspore: fruit, dispersed by car passengers.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to Europe (Balkan Peninsula, Turkey and Caspian region).**Botanical subregions:** CC NT; Vic., S.A.**Distribution Sydney area:** Widespread.**Select locations:** Kangaroo Valley (1934), Yarramalong, Kurmond, Mittagong.**Habitat****Habitat:** Along roadsides with past but not frequently repeated disturbance, especially near towns (Smith 1988).**Altitude:** 0–800 m **Annual rainfall:** above 900 mm**Typical local abundance:** Frequent.**Vegetation:** Roadside weeds.**Substrate:** Clay loam soils, fertile. Water table permanently low, moisture supply intermittent, fresh.**Exposure:** Indifferent–sheltered.**Conservation****Conservation:** Roadside exotic showing little invasive capacity, though able to regenerate *in situ* from its own seeds (Smith 1988).

Prunus cerasus *

AMYGDALACEAE

Sour Cherry

Life history

Growth form: Small deciduous tree.
Vegetative spread: Can form clumps by suckering from the roots.
Longevity:
Primary juvenile period:
Flowers:
Fruit/seed: Fruit globose, c.15 mm diameter, ripening to red.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to south-west Asia.
Botanical subregions: CC NT.
Distribution Sydney area: Eastern areas of State (Smith 1988).
Select locations: No specimens seen.

Habitat

Habitat: Sites of old orchards or gardens.
Altitude: **Annual rainfall:**
Typical local abundance: Rare.
Vegetation: Old orchards.
Substrate: Agricultural sites.
Exposure:

Conservation

Conservation: A remnant species of old orchards and gardens (having been planted more as a rootstock for grafted sweet cherries than in its own right) and not becoming naturalised.

Prunus laurocerasus *

AMYGDALACEAE

Cherry Laurel

Life history

Growth form: Evergreen shrub or small tree.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers:
Fruit/seed: Fruit ovoid, 15–17 mm long becoming black and soft when ripe, endocarp 12 mm long. Shed at maturity, February.
Dispersal, establishment & growth: Diaspore: fruit.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Balkan Peninsula, Turkey, Armenia and North Iran.
Botanical subregions: NT CT.
Distribution Sydney area: Upper Blue Mountains.
Select locations: Mt Wilson, Katoomba, Orange, Robertson.

Habitat

Habitat: Roadsides and in tall eucalypt forest.
Altitude: 800–1000 m **Annual rainfall:** above 1000 mm
Typical local abundance: Occasional.
Vegetation: Tall eucalypt forest with rainforest understorey (Smith 1988).
Substrate: Basalt soil, very fertile. Water table mostly low. Non-saline.
Exposure:

Conservation

Conservation: Becoming naturalised within 5 km of Robertson and in higher parts of Blue Mountains (Smith 1988).

Prunus lusitanica *

AMYGDALACEAE

Portugal Laurel

Growth form: Evergreen shrub or small tree.
Vegetative spread:
Longevity: 25–60 years.
Primary juvenile period:
Flowers: Late spring to early summer (Harden 1990).
Fruit/seed: Fruit fleshy, dark purple, $\pm$ ovoid, c. 8 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Life history

Status/origin: Exotic, native to Europe.
Botanical subregions: CT; Tas.
Distribution Sydney area: Mt Wilson (1958) only record.
Select locations: Mt Wilson.

Distribution

Habitat: Cultivated.
Altitude: 1000 m **Annual rainfall:** 1300 mm
Typical local abundance: Rare.
Vegetation: Rainforest.
Substrate: Basalt soil, very fertile.
Exposure:

Habitat

Conservation: Only recorded at one wild site, apparently from seed from a garden at Mt Wilson, not naturalised (Smith 1988).

Conservation

Prunus persica *

AMYGDALACEAE

Peach, Nectarine

Growth form: Small–medium sized deciduous tree.
Vegetative spread: No.
Longevity: 25–60 years.
Primary juvenile period:
Flowers: August–September.
Fruit/seed: Fleshy globose fruit 3–5 cm diameter with endocarp 25–30 mm long.
 Fruit shed at maturity, January.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by car passengers.
Fire response:
Interaction with other organisms:

Life history

Status/origin: Exotic, native to East Asia. Introduced for horticulture.
Botanical subregions: NC CC SC NT ST; LHI.
Distribution Sydney area: Widespread.
Select locations: Beecroft, Cheltenham, Northbridge, Bellevue Hill, Campbelltown, Kangaroo Valley.

Distribution

Habitat: Disturbed areas in sheltered gullies and beside roads.
Altitude: 0–300 m **Annual rainfall:** above 800 mm
Typical local abundance: Rare.
Vegetation:
Substrate: Sandstone gullies. Infertile soil.
 Water table permanently low, moisture supply intermittent, fresh.
Exposure: Sheltered situations; light–no shade.

Habitat

Conservation: Establishes sporadically along roadsides etc. presumably from seeds as fruit wastes by car passengers (Smith 1988). Sometimes naturalised.

Conservation

Prunus serotina *

AMYGDALACEAE

Wild Black Cherry

Life history

Growth form: Medium-large deciduous tree.**Vegetative spread:** No.**Longevity:****Primary juvenile period:****Flowers:** Spring.**Fruit/seed:** Fruit 8–10 mm diameter, purplish black, sweetish, endocarp 6 mm long (Smith 1988).**Dispersal, establishment & growth:** Diaspore: fruit.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Exotic, native to North America.

Probably derived from planted trees at 'Leuralla' (Smith 1988).

Botanical subregions: CT.**Distribution Sydney area:** Katoomba, Leura area.**Select locations:** Leura (1959).

Habitat

Habitat: Along paths and roadsides.**Altitude:** 800–1000 m**Annual rainfall:** above 1400 mm**Typical local abundance:** Frequent.**Vegetation:** Shrubland and disturbed eucalypt forest of *Eucalyptus piperita*.**Substrate:** Sandstone soils, infertile. Water table mostly low, intermittent, fresh.**Exposure:**

Conservation

Conservation: May cause local problems if allowed to invade bushland.**Euroschinus falcata** var. **falcata**

ANACARDIACEAE

Ribbonwood

Life history

Growth form: Small to medium-sized tree.**Vegetative spread:** No vegetative spread.**Longevity:****Primary juvenile period:****Flowers:** Unisexual, November–December.**Fruit/seed:** Fruit egg shaped, 6–8 mm long, purple-black.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:** One record of heavy infestations of white scale and black, sooty fungus (at Keiraville).

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC; Qld.**Distribution Sydney area:** Coastal — Gosford, Royal NP, Stanwell Park and southward.**Select locations:** North Entrance, Upper Causeway (RNP), Keiraville, Calderwood, Bass Point, Albion Park, Minnamurra Falls.

Habitat

Habitat: Coastal rainforest.**Altitude:** 0–300 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Rare.**Vegetation:** Littoral or dry gully rainforest, e.g. littoral rainforest with swampy understorey at North Entrance or with *Eucalyptus tereticornis* at Albion Park.**Substrate:** Black-grey sandy soil on hind dunes or creek bank alluvium. Soil fertile.

Water table mostly high, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Conservation status unknown.

Schinus areira * (*S. molle* var. *areira*)

ANACARDIACEAE

Pepper Tree

Life history**Growth form:** Tree to 10 m high, dioecious or sometimes polygamous.**Vegetative spread:** No.**Longevity:** Probably more than 50 years.**Primary juvenile period:****Flowers:** November–December. [August–February, April–June (Price 1963).]**Fruit/seed:** Fruit: globose drupe 4–6 mm diameter. Matures November–March.**Dispersal, establishment & growth:** Young plants may be frost-sensitive.**Fire response:****Interaction with other organisms:** Potent cause of hay-fever; leaf, bark, resin and gum have been used medicinally, the fruits have been used as an adulterant of pepper (Hurst 1942).**Distribution****Status/origin:** Exotic, native to South America.**Botanical subregions:** NC CC SC NWS NSW; Qld, Vic., S.A., W.A.**Distribution Sydney area:** Camden area.**Select locations:** Razorback, Mt Annan.**Habitat****Habitat:** Hillsides and along creeks.**Altitude:** 0–300 m **Annual rainfall:** 700–800 mm**Typical local abundance:** Frequent.**Vegetation:** Open grassland of *Themeda australis*.**Substrate:** Volcanic breccia, sandstone strata in Wianamatta Formation. Soil fertile.

Water table permanently low, moisture supply intermittent, fresh.

Exposure: Exposed–indifferent; light–no shade.**Conservation****Conservation:** Frequently cultivated, especially as a shade tree in inland NSW.

Occasionally locally naturalised.

Toxicodendron succedaneum * (*Rhus succedanea*) ANACARDIACEAE

Rhus Tree

Life history**Growth form:** Small to medium-sized deciduous tree to 5 m high, dioecious.**Vegetative spread:** No.**Longevity:** Probably 20–40 years.**Primary juvenile period:****Flowers:** [Very late September–very early November (Price 1963).]**Fruit/seed:** Fruit: globose drupe 6–10 mm long, matures May–September.**Dispersal, establishment & growth:** Diaspore: fruit, bird dispersed. Fruit reported from pellets of Currawongs (Buchanan 1989). Seedlings commonly occur in urban bushland but not known whether many survive to adults.**Fire response:****Interaction with other organisms:** Contains urushiol, a lacquer-like phenolic compound, used for varnishing in Asia, causes severe contact dermatitis (Blackwell 1990).**Distribution****Status/origin:** Exotic, native to E Asia, introduced as garden plant.**Botanical subregions:** CC.**Distribution Sydney area:** Sydney suburban area.**Select locations:** Pennant Hills, Garigal NP (rare), Mosman, Lane Cove NP (Clarke 1987).**Habitat****Habitat:** Bushland in urban areas.**Altitude:** **Annual rainfall:****Typical local abundance:** Rare–occasional.**Vegetation:** Seedlings establish in urban bushland.**Substrate:** Various soils, particularly fertile.**Exposure:****Conservation****Conservation:** Can cause painful allergic reactions (Monaghan & McMaugh 1987) and is a declared noxious plant in all areas of the state. Naturalises in suburban gardens. Minor weed problem in urban bushland (McLoughlin & Rawling 1990).

Actinotus forsythii

APIACEAE

Life history

Growth form: Diffuse, wiry, procumbent herb with stems to 50 cm long.

Vegetative spread: No.

Longevity: Short-lived, generally dies within a year although there are some longer-lived individuals at particular 'wetter' sites (P. Hind pers. comm.).

Primary juvenile period: About 9 months.

Flowering in February following winter fire on Newnes Plateau (P. Hind pers. comm.).

Flowers: Pink, January–April, September–October (limited data).

Fruit/seed: Fruit: 1-seeded mericarp, 2 mm long, matures Jan–May, peak possibly March–April.

Dispersal, establishment & growth: Diaspore: fruit? Recruitment fire-related but mainly in autumn regardless of time of fire and possibly triggered by second stimulus (P. Hind pers. comm.). [No success in germinating seeds (P. Hind pers. comm.).] Starts as a rosette, as it branches cauline leaves develop and rosette leaves die back. Thick taproot which withers away as food store is used up for inflorescence.

Fire response: Probably killed by fire but usually seen only following fires.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: SC CT ST; Vic.

Distribution Sydney area: Upper Blue Mountains, rare.

Select locations: Clarence, Blackheath, Mt Hay, Narroreneck, Kanangra Walls.

Habitat

Habitat: Heathland on cliff tops, moist conditions.

Altitude: 900–1100 m **Annual rainfall:** above 1000 mm

Typical local abundance: Occasional–rare.

Vegetation: Heathland, only noted in burnt areas.

Substrate: Very rocky shallow soil on sandstone. Very infertile soil, poorly drained.

Water table mostly high, moisture supply intermittent, fresh.

Exposure: Adults reported in exposed situations and in deep shade–mid shade, although perhaps seedlings may require higher light conditions.

Conservation

Conservation: Rare, Newnes Plateau northern limit — localised and poorly known.

Actinotus gibbonsii

APIACEAE

Life history

Growth form: Short-lived herb with ascending or decumbent stems to 30 cm long.

Vegetative spread: Reported to form small rosettes that spread rapidly (P. Hind pers. comm.).

Longevity: Short-lived, generally dies within a year (P. Hind pers. comm.).

Primary juvenile period: Less than 1 year.

Flowers: Pink, January, May.

Fruit/seed: Fruit: 1-seeded mericarp, 1–1.8 mm long of 2 fruitlets, seeds black with white hairs.

Dispersal, establishment & growth: Diaspore: fruit? Recruitment fire-related, recorded from sites burnt in previous year — seedlings appear in autumn regardless of time of fire and possibly triggered by second stimulus (P. Hind pers. comm.). Forms small rosettes that spread rapidly.

Taproot thick, then withers away as plant matures (P. Hind pers. comm.).

[No success in germinating seeds (P. Hind pers. comm.).]

Fire response: Probably killed by fire.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: SC NT CT ST NWS CWS NWP SWP; Qld.

Distribution Sydney area: Newnes Plateau.

Select locations: Newnes SF (1 site) (1992).

Habitat

Habitat: Ridge with rock platform.

Altitude: 1000 m **Annual rainfall:** above 1000 mm

Typical local abundance: Occasional–abundant.

Vegetation: Heath of *Leptospermum* and *Calytrix*, also occurs in woodland (P. Hind pers. comm.).

Substrate: Shallow sandy soil on sandstone, low nutrient.

Exposure:

Conservation

Conservation: Rare, not well conserved.

Actinotus helianthi**APIACEAE**

Flannel Flower

Life history

Growth form: Herb 30–90 cm high, perennial or appearing to be annual by flowering the first season, sometimes becoming woody.

Vegetative spread: No vegetative spread.

Longevity: Generally short, 4–5 years. A 'headland' form may survive 15 years unburnt and then survive fire because of its thick 1 cm diameter stems.

Primary juvenile period: 2–4 years (Benson 1985). Generally attains flowering maturity after two years (1.5 years at North Head Clemens & Franklin 1980).

Flowers: White–creamish, in head-like umbels surrounded by bracts 2–4 cm long. Flowers throughout the year, mainly November–May.

Fruit/seed: Fruit: 1-seeded mericarp, 3.2–5 mm long with silky hairs.

Dispersal, establishment & growth: Diaspore: mericarp, wind-dispersed. Recruitment from soil-stored seedbank. Soil-stored seed may survive for 15 years unburnt (at Mosman).

Seeds germinate rapidly after fire or disturbance such as clearing. Very limited germination may occur at undisturbed sites. May need rain for germination. Growth period erratic, probably related to rainfall and light availability. Abundance may indicate recent fire (0–4 years) or disturbance.

Vigorous seedling establishment on exposed sand in absence of fire (e.g. at North Head).

Fire response: Killed and re-established from soil-stored seed. Old plants of 'headland' form with thick stems (1 cm diameter) may be unaffected (e.g. at Marley).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS NWP; Qld.

Distribution Sydney area: Widespread but localised, Coast and Blue Mountains.

Select locations: Putty, Gosford, Putty, Broken Bay, Turramurra, Frenchs Forest, North Head, Kurnell, Thirlmere Lakes, Austinmer, Nowra, Springwood, Bell, Mittagong.

Habitat

Habitat: Sandstone ridges.

Altitude: 0–1200 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent.

Vegetation: Open-forest, and heath on coastal headlands and old dunes.

Substrate: Sandy well-drained soils from sandstone or sand dunes. Clay soils on coastal headlands. Very infertile soil. Water table permanently low, moisture supply intermittent, fresh.

Exposure: Exposed–indifferent. Light shade–none.

Conservation

Conservation: Probably adequately conserved.

Actinotus minor**APIACEAE**

Lesser Flannel Flower

Life history**Growth form:** Perennial herb, diffuse, with wiry branches.**Vegetative spread:** No vegetative spread.**Longevity:** 25–60 years (D. Keith pers. comm.) Life expectancy may be promoted by periodic fire. Reported as annuals at Hassans Walls.**Primary juvenile period:** 3 years (Benson 1985), to more than 5 years (D. Keith pers. comm.).**Flowers:** White, peak January, occasionally throughout the year.**Fruit/seed:** Fruit: 1-seeded mericarp, 1.9–2.9 mm long, pubescent.**Dispersal, establishment & growth:** Diaspore: seed, ant-dispersed (Rice & Westoby 1981).

Soil-stored seedbank. Recruitment mainly after fire (D. Keith pers. comm.).

Fire response: Variable, killed by high intensity fires, but resprouts with lower intensity fires.

Secondary juvenile period 1 year (D. Keith pers. comm.). Seedling recruitment following fire.

Interaction with other organisms:**Distribution****Status/origin:** Native.**Botanical subregions:** CC SC CT ST.**Distribution Sydney area:** Coast and Blue Mountains, widespread. Northern limit Ourimbah.**Select locations:** Gosford, Pennant Hills, Waterfall, Wilton, Carrington Falls, Tallong, Woodford, Wentworth Falls, Hassans Walls, West Head, Turrumurra, Frenchs Forest.**Habitat****Habitat:** Ridges and open areas.**Altitude:** 0–1200 m**Annual rainfall:** 1000–1400 mm**Typical local abundance:** Frequent.**Vegetation:** Common in heathland and sandstone scrub.**Substrate:** Almost always on sandy soils on Sandstone. Very infertile soils. Water table mostly low, though sites sometimes locally moist; moisture supply intermittent, fresh.**Exposure:****Conservation****Conservation:** Probably well-conserved in sandstone areas.**Aegopodium podagraria *****APIACEAE**

Goutweed, Ground Elder

Life history**Growth form:** Perennial herb with hollow, grooved stems 50–100 cm high.**Vegetative spread:** Spreads by far-creeping rhizome.**Longevity:****Primary juvenile period:****Flowers:****Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 3–4 mm long.**Dispersal, establishment & growth:** Diaspore: mericarp, possibly also vegetative.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to Eurasia.**Botanical subregions:** CT ST.**Distribution Sydney area:** Fitzroy Falls.**Select locations:** Fitzroy Falls — no specimens in NSW Herbarium**Habitat****Habitat:** Pasture or garden areas.**Altitude:** 700 m**Annual rainfall:** 1200 mm**Typical local abundance:****Vegetation:** Pasture or garden.**Substrate:****Exposure:****Conservation****Conservation:** Recorded as potentially troublesome weed in pasture or garden areas near Fitzroy Falls, Canberra and Cooma (Harden 1992).

Ammi majus ***APIACEAE**

Bishop's Weed

Life history**Growth form:** Erect to spreading annual or biennial herb, 25–75 cm high.**Vegetative spread:****Longevity:** 1–2 years.**Primary juvenile period:****Flowers:** White, August–February (Price 1963).**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 1.5–2 mm long, matures January.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:** Livestock grazing the plant and poultry-fed mixtures containing its seed may become photosensitive, leading to cellular damage and inflammation (Auld & Medd 1987).**Distribution****Status/origin:** Exotic, native to Europe, Asia and N Africa, probably introduced as garden plant.**Botanical subregions:** NC CC CT ST NWS CWS SWS NWP SWP NFWP; Qld, Vic., S.A., W.A.**Distribution Sydney area:****Select locations:** Hazelbrook (1921), Bathurst (1904, 1921).**Habitat****Habitat:** Weed of cultivated and disturbed ground.**Altitude:** above 700 m**Annual rainfall:** above 600 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Weed of cultivated and disturbed ground, rare.**Apium graveolens *****APIACEAE**

Celery

Life history**Growth form:** Erect biennial herb to 1 m high.**Vegetative spread:** No.**Longevity:** Less than 2 years.**Primary juvenile period:****Flowers:** White, November–January. Probably insect-pollinated.**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), ovoid 1.5–2.5 mm long.**Dispersal, establishment & growth:** Diaspore: ribbed mericarps. Water-dispersed (Carr *et al.* 1992).**Fire response:****Interaction with other organisms:** Cultivated as a vegetable. Workers in celery-canning industry suffer dermatitis after handling the plant; some people develop a rash after ingestion (Hurst 1942).**Distribution****Status/origin:** Exotic, native to Europe, probably introduced as a vegetable.**Botanical subregions:** CC SWP; Vic., Tas., S.A., W.A., N.T.**Distribution Sydney area:** Liverpool–Picton.**Select locations:** Liverpool, Leumeah (1965), Campbelltown, Picton.**Habitat****Habitat:** Riverbank.**Altitude:** 0–200 m**Annual rainfall:** 700–900 mm**Typical local abundance:** Rare.**Vegetation:** Probably with other weedy species.**Substrate:** Sandy soil, moist depressions. Soil fertile, water table mostly high, moisture supply intermittent, fresh.**Exposure:****Conservation****Conservation:** Cultivated as a vegetable and locally naturalised in the Liverpool–Picton area.

Apium prostratum subsp. **prostratum** var. **filiforme**

APIACEAE

Sea Celery

Life history**Growth form:** Biennial or perennial prostrate herb with branches 30–70 cm long, stems hollow, grooved.**Vegetative spread:** No.**Longevity:** Biennial or perennial.**Primary juvenile period:****Flowers:** White, October–May. Insect pollinated (Cook 1990).**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 1.3–2.5 mm long, matures December–May.**Dispersal, establishment & growth:** Diaspore: ribbed mericarps.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC; Qld, Vic., Tas., S.A., W.A., N.Z.**Distribution Sydney area:** Coastline and lake foreshores.**Select locations:** Narrabeen, Kurnell, Cronulla, Austinmer, Gerringong, Minnamurra River.**Habitat****Habitat:** Coastline and lake foreshores.**Altitude:** 0–10 m**Annual rainfall:** above 1400 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Saltmarsh — widespread in the upper marsh — often amongst *Juncus kraussii*.

Generally in damper sites but occasionally in dry sandy areas (Adam 1981).

Substrate: Fertile soil. Water table permanently high, moisture supply continuous, saline.**Exposure:****Conservation****Conservation:****Apium prostratum** subsp. **prostratum** var. **prostratum**

APIACEAE

Sea Celery

Life history**Growth form:** Biennial or perennial prostrate herb with branches 30–70 cm long, stems hollow, grooved.**Vegetative spread:** No.**Longevity:** Biennial or perennial.**Primary juvenile period:****Flowers:** White, September–March. Insect pollinated (Cook 1990).**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 1.3–2.5 mm long.**Dispersal, establishment & growth:** Diaspore: ribbed mericarps.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC CWS; Qld, Vic., Tas., S.A., W.A., N.Z.**Distribution Sydney area:** Coastline and lake foreshores.**Select locations:** Wondabyne, Berowra Creek, Narrabeen, Cronulla, Lake Illawarra, St Georges Basin.**Habitat****Habitat:** Coastal headlands, cliff flush habitats.**Altitude:** 0–20 m**Annual rainfall:** above 1400 mm**Typical local abundance:** Frequent.**Vegetation:** Scattered cliff dwelling herbs.**Substrate:** Wet soil pockets near cliff base, rocky ledges. Fertile soil. Water table permanently high, moisture supply continuous, saline.**Exposure:****Conservation****Conservation:** Probably adequately conserved. Ecological differences between *Apium prostratum* var. *prostratum* and *Apium prostratum* var. *filiforme* are not clear.

Bupleurum lancifolium * (*B. subovatum*, misappl. in NSW) **APIACEAE****Life history**

Growth form: Erect annual herb, 30–70 cm high, with stem-clasping leaves.

Vegetative spread:

Longevity: Annual.

Primary juvenile period:

Flowers: Yellow-green, October–December.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), ovoid to globose 3–5 mm long, matures November (limited data).

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to southern Europe, possibly introduced in 'plant rubbish from Palestine' (W.M. Carne, Herbarium note 1919).

Botanical subregions: NC CC CT ST CWS; W.A.

Distribution Sydney area: Localised records.

Select locations: Beecroft (1919), Orange (1912), only records for the area.

Habitat

Habitat: Waste ground.

Altitude: 0–900 m

Annual rainfall: above 1000 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Occasional weed of waste ground.

Centella asiatica**APIACEAE**

Pennywort

Life history

Growth form: Perennial herb, stems creeping and rooting at the nodes.

Vegetative spread: Spreads by stems creeping and rooting at nodes.

Longevity: Indeterminate.

Primary juvenile period:

Flowers: Pink–crimson, or purple or white, November–December.

Insect-pollinated or perhaps autogamous (Cook 1990).

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), matures February–April.

Dispersal, establishment & growth: Diaspore: flattened mericarps, dispersal unknown, probably water or animals (Cook 1990). Possibly a coloniser of disturbed sites. Growth rate medium.

Fire response: Probably resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT SWS; LHI, all States except N.T., Asia, Pac.

Distribution Sydney area: Coast & Hawkesbury River area.

Select locations: Pymble, Neilson Park, Centennial Park, Otford, St Albans, Wisemans Ferry, Longneck Lagoon.

Habitat

Habitat: Margins of swamps; damp places by roadsides, foreshores.

Altitude: 0–200 m

Annual rainfall: above 700 mm

Typical local abundance: Occasional–frequent. Varies between years, possibly depending on amount of rain (P. Adam pers. comm.).

Vegetation: Various — littoral rainforest e.g. with *Eucalyptus botryoides*; or coastal scrub e.g. with *Kunzea ambigua*; or wetland margins with seasonal herbland e.g. *Juncus usitatus*, or herbaceous roadside weedy vegetation, woodland.

Substrate: Moderately fertile soils, some clay influence, poorly drained. Loamy clay soils from shales or alluvium, fertile. Water table mostly high, moisture supply continuous, fresh.

Exposure: Indifferent or sheltered; light shade–no shade.

Conservation

Conservation: Probably adequately conserved.

Conserved in Western Sydney (Benson & McDougall 1991).

Centella cordifolia

APIACEAE

Life history

Growth form: Creeping perennial herb, rooting at the nodes.
Vegetative spread: Spreads by long creeping runners.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Purple, late summer–autumn.
Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 4–5 mm wide.
Dispersal, establishment & growth: Diaspore: ?mericarp.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT; Vic., Tas., S.A., W.A.
Distribution Sydney area: Coastal Sydney and Illawarra.
Select locations: Penshurst, Picton Lakes, Mt Keira, Long Swamp (Kodala *et al.* 1992), Berry.

Habitat

Habitat: Moist sites; upland mire (Kodala *et al.* 1992).
Altitude: 0–620 m **Annual rainfall:** above 800 mm
Typical local abundance: Rare–occasional.
Vegetation: With sedges and wet heath shrubs.
Substrate: Peaty or sandy wet ground.
Exposure: Possibly needing light.

Conservation

Conservation: Few records, distribution poorly known.

Ciclospermum leptophyllum * (*Apium leptophyllum*)

APIACEAE

Slender Celery

Life history

Growth form: Erect annual herb with finely divided leaves.
Vegetative spread: No.
Longevity: Less than 2 years.
Primary juvenile period: Less than 1 year.
Flowers: White, throughout the year but mainly October–January. Probably insect-pollinated.
Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 1–3 mm long, matures September–February.
Dispersal, establishment & growth: Diaspore: ribbed mericarps.
 Establishment probably related to disturbance.
Fire response:
Interaction with other organisms: Reported to taint milk when grazed by dairy cattle (Auld & Medd 1987).

Distribution

Status/origin: Exotic, native to America.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP; Qld, Vic., N.T., S.A.
Distribution Sydney area: Coast and western Sydney.
Select locations: Devlins Creek, Woollahra, Hawkesbury (1883), Nortons Basin, Leumeah, Mt Annan, Stanwell Park, Shellharbour.

Habitat

Habitat: Railway, roadside and creek banks, wetlands.
Altitude: 0–200 m **Annual rainfall:** above 700 mm
Typical local abundance: Frequent.
Vegetation: Open–barren ground, disturbed sites, or amongst tall herb growth.
Substrate: Sandy alluvial soil, clay soil from Wianamatta Shale.
 Soil fertile–infertile, water table mostly low, moisture supply intermittent, fresh.
Exposure: Indifferent to exposure; mid–light shade.

Conservation

Conservation: Weed of gardens, roadsides and other disturbed areas.

Conium maculatum ***APIACEAE**

Hemlock

Life history

Growth form: Robust annual or biennial herb 1–2.5 m high, with long white taproot; strong disagreeable mousy odour when brushed or damaged.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period:

Flowers: August–January, peak November.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 4 mm long, matures September–February.

Dispersal, establishment & growth: Diaspore: mericarp. Animal, water and vegetative dispersal (Carr *et al.* 1992). Seeds germinate in autumn, plants develop rapidly in winter and spring, some produce flowering stems in spring and die in summer; others remain vegetative until the second spring and are biennial; establishes rapidly after autumn rains, can preclude other vegetation (Parsons 1976).

Fire response:

Interaction with other organisms: All parts of the plant are poisonous, particularly almost ripe fruit; responsible for deaths of children and stock (Hurst 1942). Ancient Greeks mixed it into poison cups to execute political prisoners and it was once used as a sedative (Low 1990). Livestock generally do not graze the plant but contaminated fodder may cause problems (Auld & Medd 1987). Extracts used as arrow poisons by North American Indians; used medicinally in treating tumours, ulcers and gout (Parsons 1976).

Distribution

Status/origin: Exotic, native to Europe, Asia, probably a garden escape.

Introduced as garden plant; recorded as being a naturalised noxious weed in 1907 (Parsons 1976).

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP; Qld, Vic., Tas., S.A.

Distribution Sydney area: Widespread.

Select locations: Leichhardt (1907), Pennant Hills, Regentville, Hoxton Park, Albion Park, Little Hartley, Carcoar, Abercrombie Caves, Wollondilly River.

Habitat

Habitat: Creek banks, waste areas.

Altitude: 0–1000 m

Annual rainfall: 600–1200 mm

Typical local abundance: Frequent.

Vegetation: Other weeds of wasteland, riparian vegetation e.g. *Casuarina cunninghamia*.

Substrate: Floodplain and riverbank alluvium, fertile soil.

Water table mostly high, moisture supply continuous, fresh.

Exposure:

Conservation

Conservation: Weed of disturbed sites. Proclaimed noxious weed in many shires.

Daucus carota ***APIACEAE**

Wild Carrot

Life history

Growth form: Erect biennial herb 30–150 cm high.

Vegetative spread: No.

Longevity: 2 years.

Primary juvenile period:

Flowers: White or pinkish, November–March.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), ovoid, 3–4 mm long with spines.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Eurasia and North Africa, escape from cultivation.

Botanical subregions: NC CC SC NT NWS CWS; Vic., Tas., S.A.

Distribution Sydney area: Widespread.

Select locations: Normanhurst (1963), Hornsby, Bathurst (1896).

Habitat

Habitat: Roadside.

Altitude: 0–1000 m

Annual rainfall: above 600 mm

Typical local abundance: Frequent.

Vegetation: With *Imperata cylindrica*, *Pteridium esculentum*, *Lonicera japonica*.

Substrate: Probably sandy clay soil, well-drained. Infertile soil. Water table permanently low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Rare escape from cultivation.

Daucus glochidiatus**APIACEAE**

Native Carrot

Life history**Growth form:** Annual herb, usually erect, 8–60 cm high.

Appears to include several forms that need further botanical work.

Vegetative spread: No.**Longevity:** Less than 1 year.**Primary juvenile period:****Flowers:** White or pink–crimson, spring–summer.**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 3–5 mm long, with barbed prickles, recorded at various times.**Dispersal, establishment & growth:** Diaspore: mericarp, animal dispersed. Burr-like fruits adhere to wool & clothing.**Fire response:** Seedlings recorded less than 1 year after fire (Purdie 1977).**Interaction with other organisms:** Reputed to taint milk if large amount is ingested (Auld & Medd 1987).**Distribution****Status/origin:** Native.**Botanical subregions:** All divisions; all States, N.Z.**Distribution Sydney area:** Widespread.**Select locations:** Mt Yengo, Mooney Mooney Creek, St Ives, Nortons Basin, Richmond, Blackheath, Cullen Bullen, Jenolan Caves, Kangaroo Valley, Wingello.**Habitat****Habitat:** Wetland.**Altitude:** 0–1000 m**Annual rainfall:** 700–1200 mm**Typical local abundance:** Occasional.**Vegetation:** Dry–wet eucalypt open-forest and edge of rainforest.**Substrate:** Basalt scree and volcanic necks, as well as shale. Very fertile–fertile soil.

Water table mostly low, moisture supply intermittent, fresh.

Exposure:**Conservation****Conservation:** Vulnerable in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.**Eryngium maritimum *****APIACEAE****Life history****Growth form:** Robust perennial herb to 50 cm high.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** Pale mauve, December–May.**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 4.5–6 mm long, covered with acutely pointed scales.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to Europe.**Botanical subregions:** NC CC.**Distribution Sydney area:** Budgewoi north (to Taree).**Select locations:** Budgewoi (1965).**Habitat****Habitat:** Coastal sand dunes.**Altitude:** 0–10 m**Annual rainfall:** 1200 mm**Typical local abundance:****Vegetation:****Substrate:** Coastal sand dunes.**Exposure:****Conservation****Conservation:** Locally naturalised exotic.

Eryngium pandanifolium * (E. decaisneanum) APIACEAE**Life history****Growth form:** Erect perennial herb to 4 m high.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** Greenish-white, February–March.**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps) 2.5 mm long, covered with bladdery scales.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to tropical South America.**Botanical subregions:** CC.**Distribution Sydney area:** Centennial Park.**Select locations:** Centennial Park (1913, 1953).**Habitat****Habitat:** Swamp margins.**Altitude:** 0–50 m**Annual rainfall:** 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Edge of *Melaleuca* swamp.**Substrate:** Silt, infertile. Water table permanently high, moisture supply continuous, fresh.**Exposure:****Conservation****Conservation:** Appears to be very locally naturalised exotic.**Eryngium rostratum** (E. ovinum)

APIACEAE

Blue Devil

Life history**Growth form:** Annual or short-lived perennial herb (thistle-like), upper parts often metallic blue.**Vegetative spread:****Longevity:** Annual or short-lived perennial.**Primary juvenile period:****Flowers:** Blue, November–January. Leaves wither when plant is flowering.**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps) 2.5–4 mm long covered with acute bladdery scales and crowned by persistent sepals, matures December (limited data).**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC NT CT ST CWS SWS NWP SWP; all States.**Distribution Sydney area:** Bathurst area and Dividing Range, also Richmond, Riverstone.**Select locations:** Valley of the western Blue Mtns, Wallerawang, Hill End, Bathurst, Blayney, Wombeyan Caves, Richmond (1906), Riverstone.**Habitat****Habitat:** Moist, cool sites.**Altitude:** 800–1000 m**Annual rainfall:** 800–1100 mm**Typical local abundance:** Occasional.**Vegetation:** Pastures and woodland.**Substrate:** Heavy soils.**Exposure:****Conservation****Conservation:** Possibly rare, mostly old records.

Eryngium vesiculosum

APIACEAE

Prostrate Blue Devil or Prickfoot

Life history

Growth form: Perennial herb (thistle-like) with prostrate branches to 30 cm long.

Vegetative spread: Limited.

Longevity: Short-lived.

Primary juvenile period:

Flowers: Blue, December–March.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps) 5–6 mm long, covered with blunt bladdery scales, matures May (limited data).

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NT CT ST NWS SWS; Vic., Tas., N.Z.

Distribution Sydney area: Valleys of the western Blue Mountains, rare.

Select locations: Lidsdale, Hartley Vale, Mt Victoria.

Habitat

Habitat: Moist sites, edges of swamps.

Altitude: 700–800 m **Annual rainfall:** 800–1000 mm

Typical local abundance: Frequent.

Vegetation: Grassy meadow, edge of swamp.

Substrate: Alluvial soil, fertile. Water table mostly high, non-saline.

Exposure:

Conservation

Conservation: Rare, mostly old records.

Foeniculum vulgare *

APIACEAE

Fennel

Life history

Growth form: Erect biennial or perennial herb 1–2.5 m high with stout branched taproot.

Vegetative spread: No.

Longevity:

Primary juvenile period: 1.5–2 years.

Flowers: Yellow, December–very early May (Price 1963).

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 4–10.5 mm long, matures February–May.

Seeds aromatic.

Dispersal, establishment & growth: Diaspore: mericarp. Germinates at almost any time of the year, flowering stems produced from the perennial crown each spring (Parsons 1976). Distributed by vehicles, machinery, coats of animals, water and as a contaminant of agricultural produce. Also spread by the transport of pieces of the crown by earth moving machines (Cunningham *et al.* 1981). Grows from late winter to autumn, then dies back and flowers in following season. Animal and water-dispersed (Carr *et al.* 1992). Spread by water in particular, once established it excludes other vegetation; strong smell discourages grazing by animals (Parsons 1976).

Fire response: Probably resprouts from base.

Interaction with other organisms: Cultivars used as a vegetable.

Seeds have been used as a flavouring and in ancient medicines (Parsons 1976).

Distribution

Status/origin: Exotic, native to Eurasia. Introduced as a garden/herbal plant.

Botanical subregions: NC CC SC NT CT ST NWS CWS NWP NFWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Coast and Western Sydney.

Select locations: Middle Harbour Creek, Northbridge, Centennial Park (1909), Marsfield, Richmond, Mount Annan, Menangle Park, Wollongong.

Habitat

Habitat: Roadsides and waste places. Along many creeks and drains (Parsons 1976).

Altitude: 0–200 m **Annual rainfall:** above 600 mm

Typical local abundance: Frequent.

Vegetation: With roadside weeds e.g. *Bidens*, *Sida*, *Paspalum*, but capable of forming dense infestations which exclude other vegetation.

Substrate: Clay, fertile soils from Wianamatta Shale. Moisture supply intermittent.

Exposure: Full sun.

Conservation

Conservation: Widespread, common weed, not invasive of bushland areas.

Hydrocotyle algida

APIACEAE

Pennywort

Life history

Growth form: Small prostrate herb with creeping rhizomes.
Vegetative spread: Yes.
Longevity: Indefinite.
Primary juvenile period:
Flowers: November–January.
Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 1–1.7 mm long, 1.5–2 mm wide.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST; Vic.
Distribution Sydney area: South from Ben Bullen State Forest.
Select locations: Ben Bullen SF (Harden 1992), (Limited data, specimens on loan).

Habitat

Habitat: Mossy areas or in running water.
Altitude: above 800 m **Annual rainfall:** above 800 mm
Typical local abundance:
Vegetation: Eucalypt forest.
Substrate: Shales and granites.
Exposure:

Conservation

Conservation: Ben Bullen (northern limit), poorly known.

Hydrocotyle bonariensis *

APIACEAE

Life history

Growth form: Perennial herb, with rhizomes, stems creeping and rooting at the nodes.
Vegetative spread: Spreads extensively by rhizomes running along or beneath the soil surface, vigorous coloniser species.
Longevity: Indefinite.
Primary juvenile period:
Flowers: White–creamy yellow, October–June, peak October–February.
Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 1.5–2 mm long, 2.5–3 mm wide, matures February–June.
Dispersal, establishment & growth: Diaspore: probably mericarp or stem fragments. Growth rate quick. Coloniser.
Fire response: Resprouts at ground level or below.
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to South America.
Botanical subregions: NC CC SC; LHI, Qld, Vic., S.A., W.A.
Distribution Sydney area: Coastal foreshores.
Select locations: Mooney Mooney Creek, Bayview, Narrabeen (1941), Manly, La Perouse, Kurnell, Lake Illawarra.

Habitat

Habitat: Estuaries, coastline, sand dunes and fringes of saltmarsh, cliff tops.
Altitude: 0–100 m **Annual rainfall:** above 1200 mm
Typical local abundance: Dominant–frequent.
Vegetation: Coastal dune and upper saltmarsh. Large plants are found in moister communities and smaller more succulent specimens in drier, more sandy sites (Adam 1981). Has possibly displaced *Selliera radicans* in clifftop habitats (P. Adam, pers. comm.).
Substrate: Sandy soil from sand dunes or sandstones, also filled areas, infertile. Moisture supply intermittent, saline. Drought tolerant (Clarke 1989).
Exposure: Exposed–indifferent; can grow in understory to *Casuarina glauca* so is reasonably shade-tolerant. Seedlings shade-tolerant, sun-tolerant (Clarke 1989).

Conservation

Conservation: A vigorous invasive weed species, secondary sand coloniser (Clarke 1989).

Hydrocotyle geraniifolia**APIACEAE**

Forest Pennywort

Life history**Growth form:** Creeping or climbing herb with stems to several metres long.**Vegetative spread:** Stems spread several metres radiating from central rootstock, and rooting at nodes near base.**Longevity:****Primary juvenile period:****Flowers:** White, November–January.**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 2–2.5 mm long, 3.5–3.8 mm wide, matures February–April (limited data).**Dispersal, establishment & growth:** Coloniser.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT; Vic., S.A.**Distribution Sydney area:** Widespread.**Select locations:** Gunderman, Boorai Creek, Glenbrook, Mt Banks, Royal NP, Nortons Basin, Bundanoon.**Habitat****Habitat:** Sheltered places.**Altitude:** 0–1000 m**Annual rainfall:** 1000–1400 mm**Typical local abundance:****Vegetation:** Tall moist eucalypt open-forest with herbaceous ground cover.**Substrate:** Deep soils from shales and sandstones e.g. Narrabeen Group. Soil fertile. Water table mostly high.**Exposure:** Sheltered situations, mid shade.**Conservation****Conservation:** Conservation status unknown.**Hydrocotyle laxiflora** (includ. *H. acutiloba*)**APIACEAE**

Stinking Pennywort

Life history**Growth form:** Dioecious, perennial herb to 15 cm high, creeping and rooting at the nodes.Includes *H. acutiloba* and is a taxon often misidentified.**Vegetative spread:** Creeping rhizomes spreading often more than 1 m.**Longevity:****Primary juvenile period:****Flowers:** Pale green, with an offensive odour, October–April.**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 1.5–2 mm long, 1.8–2.5 mm wide, matures February–May.**Dispersal, establishment & growth:** Dispersal — no special morphology (Westoby *et al.* 1990). Coloniser.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC NT CT ST NWS CWS SWS; Qld, Vic., Tas., S.A.**Distribution Sydney area:** Coast (rarely) and western Blue Mountains.**Select locations:** Cheltenham, Menangle, Mittagong, Hartley, Hampton, Megalong, Turondale.**Habitat****Habitat:** Moist places.**Altitude:** 0–1000 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Woodland and with herbaceous understorey e.g. *Eucalyptus dives*–*Eucalyptus viminalis* or *E. fastigata*–*Eucalyptus radiata*.**Substrate:** Sandy loam from Devonian metamorphic, granite or sandstone. Infertile soil.

Water table permanently low, moisture supply intermittent, fresh.

Exposure: Sheltered situations in light shade.**Conservation****Conservation:** Probably adequately conserved.

Hydrocotyle peduncularis**APIACEAE****Life history**

Growth form: Small, creeping herb, rooting at nodes, with aerial stems arising from nodes.
Vegetative spread: Spreads by creeping stems below or above ground in litter, occasionally mat-forming.
Longevity:
Primary juvenile period:
Flowers: Spring–Autumn.
Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 1 mm long and wide, matures April (limited data).
Dispersal, establishment & growth: Coloniser.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST; Qld, Vic., Tas.
Distribution Sydney area: Widespread.
Select locations: North Ryde, Neilson Park, Penrose (P. Kodela pers. comm.).
 (Limited data, specimens on loan).

Habitat

Habitat: Occasional weed of gardens (Harden 1992).
Altitude: 0–1000 m **Annual rainfall:** above 1200 mm
Typical local abundance:
Vegetation: Sclerophyll forest and swamps.
Substrate: Moist sites e.g. upland mire (P. Kodela pers. comm.).
Exposure:

Conservation

Conservation: Conservation status unknown.

Hydrocotyle tripartita**APIACEAE**

Pennywort

Life history

Growth form: Small, slender perennial herb, creeping and rooting at least at the lower nodes.
Vegetative spread: Yes, spreads by creeping stems, occasionally mat-forming.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Greenish, yellowish or purplish, throughout the year but mainly November–March.
Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 1 mm long, 2 mm wide.
Dispersal, establishment & growth: Coloniser.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT ST NWS; Qld, Vic., Tas., S.A., N.Z.
Distribution Sydney area: Widespread.
Select locations: Agnes Banks, Menangle, Mt Keira, Albion Park. (Limited data, specimens on loan.)

Habitat

Habitat: Margins of streams, swamp depressions.
Altitude: 0–500 m **Annual rainfall:** 750–1800 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt forest, margins of rainforest.
Substrate: Damp places, sandy soil, water table mostly high, non-saline.
Exposure: Shaded to open sites.

Conservation

Conservation: Conservation status unknown.

Hydrocotyle verticillata (H. vulgaris)

APIACEAE

Shield Pennywort

Life history

Growth form: Perennial herb with rhizomes; stems creeping and rooting at the nodes.
Vegetative spread: Rhizomes running below surface of sand or soil and rooting at nodes.
Longevity:
Primary juvenile period:
Flowers: Creamy-yellow, November–April.
Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 2 mm long, 2.5–3 mm wide.
Dispersal, establishment & growth: Coloniser.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC; Qld, Vic., S.A.
Distribution Sydney area: Georges River.
Select locations: Casula (only NSW Herbarium record).

Habitat

Habitat: Freshwater swamps, lagoons and along streams and rivers, sometimes partially submerged.
Altitude: 0–20 m **Annual rainfall:** 800 mm
Typical local abundance:
Vegetation:
Substrate: In mud on edge of lagoon.
Exposure:

Conservation

Conservation: Uncommon, probably inadequately conserved.

Lilaeopsis polyantha

APIACEAE

Life history

Growth form: Perennial, emergent herb, stems creeping and rooting at the nodes.
Vegetative spread: Spreads by creeping stems.
Longevity: Indefinite.
Primary juvenile period:
Flowers: White, November and March.
Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps) 1.5–3.5 mm long, matures March.
Dispersal, establishment & growth: Diaspore: corky mericarp, released when dry and dispersed by wind to accumulate in nearby mud cracks but also possibly dispersed long distances by birds (Affolter, 1985), possibly also spread by vegetative fragments.
Fire response:
Interaction with other organisms: Possibly grazed by waterbirds (Affolter 1985).

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT CT ST SWS; Qld, Vic., Tas., S.A.
Distribution Sydney area: Widespread.
Select locations: Avoca Lagoon, Dee Why Lagoon (P. Adam), Richmond (1992), Penrose (P. Kodela).

Habitat

Habitat: Lagoon margins, upland mire (P. Kodela pers. comm.).
Altitude: 0–620 m **Annual rainfall:** above 700 mm
Typical local abundance: Rare–frequent.
Vegetation: Herbland.
Substrate: Alluvial sand, infertile. Fresh or brackish water to 30 cm deep or on wet mud on the margins of water bodies. Water table mostly high, moisture supply continuous, brackish–fresh.
Exposure: Indifferent to exposure. Usually full sun (0–30 % canopy cover) (Peter Lister pers. comm.)

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).
 Inadequately conserved.

Oreomyrrhis eriopoda

APIACEAE

Australian Carraway

Life history

Growth form: Perennial herb, 5–50 cm high, with slender taproot.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White or tinged pink, summer.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 3–6 mm long, 15–25 per umbel, matures November–January.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC SC NT ST CWS SWS; Vic., Tas., S.A.

Distribution Sydney area: Western Blue Mountains.

Select locations: Mt Coridudgy, Mt Wilson, Blackheath, Mandurama, Mt Bindo, Mittagong.

Habitat

Habitat: Woodland at higher elevation.

Altitude: 700–1100 m **Annual rainfall:** above 1000 mm

Typical local abundance: Rare.

Vegetation: Woodland with herbaceous understorey e.g. with *Eucalyptus pauciflora*–*Eucalyptus dalrympleana*.

Substrate: On red loam from metamorphics or sedimentary. Soil infertile. Water table permanently low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Probably inadequately conserved, mostly old records.

Pastinaca sativa subsp. **sativa** *

APIACEAE

Parsnip

Life history

Growth form: Erect stout biennial herb to 1.8 m high, with swollen taproot.

Vegetative spread: No.

Longevity: 2 years.

Primary juvenile period:

Flowers: Yellow, November–April.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 5–7 mm long.

Dispersal, establishment & growth: Diaspore: mericarp, possibly wind-dispersed.

Fire response:

Interaction with other organisms: Widely grown as a vegetable.

Distribution

Status/origin: Exotic, introduced as a vegetable from Europe.

Botanical subregions: NC NT CT ST; Vic., Tas., S.A.

Distribution Sydney area: Naturalised in cooler areas.

Select locations: Abercrombie Caves, Lake Conobolas.

Habitat

Habitat: Riverflats, roadsides.

Altitude: 700–900 m **Annual rainfall:** 700–1000 mm

Typical local abundance: Frequent.

Vegetation: Cleared, grassy.

Substrate: Moist ground on alluvium. Water table mostly high, moisture supply continuous, fresh.

Exposure:

Conservation

Conservation: Naturalised in cooler areas, in wasteland and on roadsides.

Platysace clelandii**APIACEAE****Life history****Growth form:** Sprawling shrub 30–60 cm high.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** White, August–February.**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 1.5 mm long, 2–2.2 mm wide, matures August, December–January, May (limited data).**Dispersal, establishment & growth:****Fire response:** Possibly resprouts.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC CT.**Distribution Sydney area:** Hornsby Plateau.**Select locations:** Running stream, Putty, Culoul Range, Wisemans Ferry, Colo Gorge, Yarramun Creek, Marramarra NP, Muogamarra NR.**Habitat****Habitat:** Dry hillsides.**Altitude:** 0–800 m**Annual rainfall:** 800–1200 mm**Typical local abundance:** Occasional.**Vegetation:** Eucalypt open-forest e.g. *Angophora costata*, *Syncarpia glomulifera*.**Substrate:** Low-moderate nutrient sandy soils from sandstone or Narrabeen series. Water table permanently low, moisture supply intermittent, well drained. May possibly be somewhat salt-tolerant — often growing within a few metres of shore in Hawkesbury River area.**Exposure:** Sheltered, mid-light shade.**Conservation****Conservation:** Local endemic species nationally coded 2RCa (Briggs & Leigh 1988).**Platysace ericoides****APIACEAE****Life history****Growth form:** Semi-prostrate or diffuse shrub 10–50 cm high. A variable species warranting further investigation.**Vegetative spread:****Longevity:** ?short.**Primary juvenile period:****Flowers:** White or cream, November–January, peak November.**Fruit/seed:** Fruit: schizocarp (of 2, 1-seeded mericarps), 1.5–2.3 mm long, dispersed immediately at maturity, January.**Dispersal, establishment & growth:** Diaspore: mericarp. Probably soil-stored seedbank.**Fire response:** Variable response: Stems killed and generally resprouts from base (Benson 1981).

Secondary juvenile period 1 year. Plants killed at Myall Lakes (Fox 1988).

Interaction with other organisms:**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT NWS CWS NWP; Qld.**Distribution Sydney area:** Widespread. Plateaus north and south of Sydney.**Select locations:** Putty, Colo Heights, Kenthurst (L.McD.), Ku-ring-gai, Kurnell, Voyager Point, Campbelltown, Burragorang, Hilltop.**Habitat****Habitat:** Dry ridges.**Altitude:** 0–900 m**Annual rainfall:** above 900 mm**Typical local abundance:** Local abundance frequent.**Vegetation:** Sclerophyll heath, scrub and forests e.g. with *Eucalyptus eximia*, *Angophora floribunda*.**Substrate:** Substrate low nutrient sandstone soils. Sandy soils, shallow (Kenthurst, L.McD.), sometimes deep, often from sandstone. Soil infertile–very infertile.

Water table permanently low, moisture supply intermittent, fresh.

Exposure: Exposed–indifferent in light–no shade.**Conservation****Conservation:** Probably adequately conserved. Mittagong southern limit.

Platysace lanceolata**APIACEAE****Life history**

Growth form: Diffuse or erect shrub, 60–150 cm high. Very variable in leaf form and has sometimes been divided into varieties on the basis of leaf shape. Hybridizes with *P. stephensonii* (Harden 1992)

Vegetative spread: No vegetative spread.

Longevity: Probably less than 25 years. [Present but rare in area not burnt for 23 years (at Elouera), not burnt for 20 years (at Mosman) and not burnt for 13 years (at Field of Mars).]

Primary juvenile period:

Flowers: White or creamy, Nov–Jul.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 1.5–2 mm long, 1.5–2.1 mm wide, dispersed immediately at maturity.

Dispersal, establishment & growth: Diaspore: mericarp. Soil-stored seedbank (Fox 1988).

Recruitment after fire or disturbance and sometimes in absence of fire (Lion Is).

Fire response: Variable response: resprouting reported at North Head (Clemens and Franklin 1980), at Darkes Forest (D. Keith pers. comm.), at Elouera (1985) accompanied by numerous seedling growth.

Killed and re-established from soil-stored seedbank at Myall Lakes (Fox 1988).

May fruit within 2 years of high intensity fire but 4 years of low intensity fire Bradley (1972).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS SWP; Qld, Vic.

Distribution Sydney area: Widespread, coastal plateaus and Blue Mountains.

Select locations: Gosford, Hornsby, Kurnell, Mt Kembla, Mt Coricudgy, Wallacia, Mt Wilson, Kanangra, Mittagong, Budderoo.

Habitat

Habitat: Steep rocky slopes and dry ridges.

Altitude: 0–1000 m

Annual rainfall: above 1000 mm

Typical local abundance: Frequent.

Vegetation: Heath or less commonly eucalypt open-forest.

Substrate: Often on rock outcrops on sandy soil from sandstone, infertile–very infertile.

Water table permanently low, moisture supply intermittent, fresh.

Exposure: Exposed–indifferent situations, light shade–full sun.

Conservation

Conservation: Probably adequately conserved.

Platysace linearifolia**APIACEAE****Life history**

Growth form: Erect or spreading shrub 40–150 cm high.

Vegetative spread: Spreads by root suckering, possibly induced by fire in some sites.

Longevity: 10–40 years, though root suckering and resprouting may possibly promote indefinite longevity. Plants 0.5 m high recorded in bush unburnt for 23 years (at Elouera) and 13 years (at Field of Mars).

Primary juvenile period: 3–4 years (Benson 1985).

Flowers: White, January–June.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 2 mm long, dispersed immediately at maturity, February–April.

Dispersal, establishment & growth: Diaspore: mericarp, probably ant-dispersed, has ant-adapted food body (Westoby *et al.* 1990). Soil-stored seedbank, main growth period September–March.

Fire response: Variable. Killed by high intensity fires but may resprout after low intensity fires on coast. Resprout and root-sucker more frequently in Blue Mountains and Colo area, also Woronora Plateau (D. Keith pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC CT; Qld.

Distribution Sydney area: Widespread, coastal plateaus and Blue Mountains.

Select locations: Bucketty, Warrah, Ku-ring-gai NP, Roseville, Davidson–Garigal NP, Audley, Austinmer, Bilpin, Springwood, Blackheath, Kanangra, Barren Grounds.

Habitat

Habitat: Ridges and hillsides.

Altitude: 0–1100 m

Annual rainfall: above 900 mm

Typical local abundance: Typical local abundance frequent.

Vegetation: Very abundant in DSF. Shrubby woodland and open-forest particularly Sydney sandstone complex.

Substrate: Gravelly–sandy loam from sandstone, soil infertile–very infertile.

Water table permanently low, moisture supply intermittent, fresh.

Exposure: Exposed–indifferent situations, light–no shade.

Conservation

Conservation: Adequately conserved.

Platysace stephensonii**APIACEAE****Life history**

Growth form: Small shrub, 25–50 cm high.

Vegetative spread: No.

Longevity: Probably short-lived, less than 10 years.

Primary juvenile period:

Flowers: October–January, peak December.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 1.7–2 mm long, 1.5–2 mm wide, matures Jan.

Dispersal, establishment & growth: Diaspore: mericarp. Dispersal: ant-adapted food body (Westoby *et al.* 1990).

Fire response: Probably resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC.

Distribution Sydney area: Coast, Broken Bay–Bundeena, Point Perpendicular.

Select locations: Ku-ring-gai Chase NP, Garigal NP (L.McD.), Belrose, La Pouse, Bundeena, Point Perpendicular.

Habitat

Habitat: Rocky outcrops on sandstone ridges.

Altitude: 0–100 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Heath and open areas e.g. with *Baeckea diosmifolia*, *Banksia oblongifolia*, *Allocasuarina distyla*.

Substrate: Rocky sandstone outcrops and ridges, possibly associated with disturbance. Skeletal low nutrient soils. Water table permanently low, moisture supply intermittent, fresh.

Exposure: Exposed–indifferent, light shade or none.

Conservation

Conservation: Local endemic species, nationally coded 3RC (Briggs & Leigh 1988).

Trachymene anisocarpa**APIACEAE****Life history**

Growth form: Erect robust annual or perennial herb 120–250 cm high with stout taproot.

Vegetative spread: Probably not.

Longevity:

Primary juvenile period:

Flowers: White, cream or pink, July–April.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 3.5 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Vic., Tas., W.A.

Distribution Sydney area: Illawarra.

Select locations: Port Kembla (1960).

Habitat

Habitat: Swampy areas.

Altitude: 20 m

Annual rainfall: 1200 mm

Typical local abundance: Occasional.

Vegetation:

Substrate: Sandy soil.

Exposure:

Conservation

Conservation: Rare, conservation status unknown.

Trachymene incisa subsp. **incisa****APIACEAE****Life history**

Growth form: Erect herb to 60 cm high, with thick perennial rootstock.

Vegetative spread: No.

Longevity:

Primary juvenile period:

Flowers: White or pinkish, September–April, peak November.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps, one often aborted), 2–3.3 mm long, matures September–April.

Dispersal, establishment & growth: Diaspore: mericarp; recruitment not fire-related, seedlings 2 cm high noted at Agnes Banks in November 1992 in undisturbed bush.

Fire response: Variable response: Resprouted from ground level at Agnes Banks (Benson 1981) and other places. Killed by fire at Myall Lakes (Fox 1988).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT NWS; Qld.

Distribution Sydney area: Coast and western Sydney.

Select locations: Toukley, Dee Why, Berry Island, Hurstville (1889), East Hills, Leumeah, Campbelltown, Appin, Agnes Banks.

Habitat

Habitat: Sandy soils.

Altitude: 0–100 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent.

Vegetation: Dry eucalypt woodland or scrub.

Substrate: Sandy soil from alluvium, windblown deposit or sandstone, very infertile. Water table permanently low, moisture supply intermittent, fresh.

Exposure: Indifferent to exposure, light shade–no shade.

Conservation

Conservation: Conservation status unknown.

Trachymene procumbens

APIACEAE

Life history

Growth form: Weak herb with slender rootstock, with stems to 30 cm long.

Vegetative spread: No.

Longevity:

Primary juvenile period:

Flowers: White, summer–autumn.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps, one may abort), 3 mm long, 4 mm wide.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Coast.

Select locations: Early record from Manly (Harden 1992).

Habitat

Habitat: Coast.

Altitude: 0–50 m

Annual rainfall: 1200 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Uncommon, Manly southern limit, status uncertain, possibly extinct.

Trachymene saniculifolia (Didiscus scapiger) APIACEAE

Life history

Growth form: Perennial robust herb to 50 cm high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White–pinkish, December–January.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 1.5–3 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CT; Asia.

Distribution Sydney area: Western Blue Mountains.

Select locations: Jenolan Caves (Blakely 1899), Boyd River Crossing, Kanangra Boyd N.P.

(Fairley & Moore 1989).

Habitat

Habitat:

Altitude: 800 m

Annual rainfall: 900–1000 mm

Typical local abundance:

Vegetation: Woodland.

Substrate:

Exposure:

Conservation

Conservation: Very restricted — only known population is in Kanangra Boyd NP.

Xanthosia atkinsoniana**APIACEAE****Life history**

Growth form: Perennial herb to 60 cm high with woody base.

Vegetative spread: No.

Longevity:

Primary juvenile period:

Flowers: White–pinkish, November–April, peak December–January.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 2.5 mm long, matures January–March.

Dispersal, establishment & growth:

Fire response: Resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC NT CT ST; W.A.

Distribution Sydney area: Blue Mountains.

Select locations: Putty, Mt Kindarun, Mt Coricudgy, Bilpin, Mt Irvine, Clarence, Blackheath, Mittagong, Penrose, Marulan.

Habitat

Habitat: Open-forest on ridges.

Altitude: 0–1000 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent–occasional.

Vegetation: Open eucalypt forest e.g. *Angophora costata*, *Eucalyptus punctata*, *E. sieberi*.

Substrate: Sandy soils or sand over clay from sandstone sometimes on edge of wet areas. Infertile soil.

Water table permanently low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Conservation status unknown.

Xanthosia dissecta**APIACEAE**

Cut-leaved *Xanthosia*

Life history

Growth form: Tufted subshrub to 15 cm high, with woody rootstock.

Vegetative spread:

Longevity: 5–20 years (D. Keith pers. comm.).

Primary juvenile period: Primary juvenile period more than 5 years (D. Keith pers. comm.).

Flowers: White, August.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 2 mm long, matures December.

Dispersal, establishment & growth:

Fire response: Resprouts at ground level or below. Secondary juvenile period 1 year (D. Keith pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC CT ST; Vic., Tas.

Distribution Sydney area: Upper Blue Mountains and Bulli (1 record).

Select locations: Wentworth Falls, Blackheath, Boyd Crossing, Bulli Lookout.

Habitat

Habitat: Upland swamps.

Altitude: 0–1000 m

Annual rainfall: above 1400 mm

Typical local abundance: Rare.

Vegetation: Wet heath and sedge swamps e.g. with *Xyris*, *Restio*, *Leptospermum*.

Substrate: Sandy soil from sandstone, very infertile. Water table permanently high, moisture supply continuous, fresh.

Exposure:

Conservation

Conservation: Uncommon, Blackheath northern limit, conservation status unknown.

Xanthosia pilosa (incl. *X. vestita*)**APIACEAE****Life history**

Growth form: Erect or diffuse variable shrub 30–65 cm high. Sometimes with very stout rootstock (L.McD.). Plants generally tomentose but this varies, and there are various forms apparent but more work is needed.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Pale green–creamy white, at any time, peak October–November.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 2 mm long.

Dispersal, establishment & growth: Diaspore: fruit, ant-dispersed (Westoby *et al.* 1981).

Fire response: Various response. Different forms, one killed, another resprouts from base or below — both seen in Garigal NP (L.McD.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Qld, Vic., Tas.

Distribution Sydney area: Widespread — Coast and Blue Mountains.

Select locations: Mt White, Woy Woy, Galston, Dee Why, Cordeaux Dam, Kurrajong Heights, Springwood, Mt Victoria, Belmore Falls, Kanangra, Penrose.

Habitat

Habitat: Sandy soil near creeks.

Altitude: 0–1000 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent.

Vegetation: Eucalypt open-forest e.g. with *Eucalyptus piperita*.

Substrate: Sandy soils on sandstone hillsides and gullies sometimes near wet cliffs, very infertile soils. Water table mostly low, moisture supply intermittent, fresh.

Exposure: Sheltered situations, mid shade.

Conservation

Conservation: Probably adequately conserved.

Conserved in Western Sydney (Benson & McDougall 1991).

Xanthosia tridentata**APIACEAE**

Rock Xanthosia

Life history

Growth form: Diffuse perennial shrub to 30 cm high.

Vegetative spread: No.

Longevity: Less than 20 years (D. Keith pers. comm.).

Primary juvenile period: Less than 6 years (Benson 1985, D. Keith pers. comm.).

Flowers: Pale green–cream, September–February, peak November.

Fruit/seed: Fruit: schizocarp (of 2, 1-seeded mericarps), 3 mm long.

Dispersal, establishment & growth: Diaspore: fruit, ant-dispersed (Rice & Westoby 1981).

Fire response: Killed and re-establish from soil-stored seed (D. Keith pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC CT ST; Vic., Tas., W.A.

Distribution Sydney area: Widespread — coastal and Lower Blue Mountains.

Select locations: Mt White, Oxford Falls, Pennant Hills, Manly, Kentlyn, Wilton, Mt Keira, Bilpin, Springwood, Woodford.

Habitat

Habitat: Rocky sandstone hillsides.

Altitude: 0–600 m

Annual rainfall: above 1000 mm

Typical local abundance: Occasional.

Vegetation: Eucalypt woodland and scrub e.g. with *Eucalyptus gummifera*, *E. sieberi*, *E. racemosa*, *E. piperita*, *Angophora costata* sometimes in regrowth vegetation.

Substrate: Rocky sandstone hillsides or sides of gullies, grey, sandy, very infertile soils, sometimes damp. Water table mostly low, moisture supply intermittent, fresh. Sometimes poorly drained.

Exposure: Light–no shade.

Conservation

Conservation: Probably adequately conserved.

Alyxia ruscifolia

APOCYNACEAE

Prickly Alyxia

Life history

Growth form: Erect shrub to 2.5 m high.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Spring–Autumn.
Fruit/seed: Fruit, orange berries 8–11 mm diam, matures in April.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC; LHI, Qld, N.T., N.G., Moluccas.
Distribution Sydney area: West of Wollongong.
Select locations: Goondarrin Creek, west of Wollongong in Water Board Catchment Area (only record in area).

Habitat

Habitat: Rainforest near creek.
Altitude: 330–400 m **Annual rainfall:** above 1600 mm
Typical local abundance: Occasional, total population probably less than 50 plants.
Vegetation: Warm temperate rainforest, simple Notophyll Vine-forest e.g. *Ceratopetalum–Acmena–Doryphora* association.
Substrate: Upper Narrabeen Group geology. Soil fertile.
Exposure: Southern aspect.

Conservation

Conservation: Localised disjunct population, southern limit; previous southern record Willams River. Most of the rainforest in the area was visited but this was the only location where the species was seen; the species has not yet been seen anywhere else in Illawarra (K. Mills 1982 pers. comm.). Regionally rare in Illawarra region (Mills 1988).

Mandevilla laxa *

APOCYNACEAE

Chilean Jasmine

Life history

Growth form: Woody climber with milky latex.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: November–January.
Fruit/seed: Fruit: follicle 25–40 cm long, matures Autumn. Seed dispersed in late Autumn (Rowell 1970).
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Bolivia & Argentina, introduced as garden plant.
Botanical subregions: NC CC NWS.
Distribution Sydney area: Grown in gardens and naturalised in a few places around Sydney.
Select locations: Northbridge (1952), Ku-ring-gai Chase (rare).

Habitat

Habitat: Creekbanks.
Altitude: 0–100 m **Annual rainfall:** above 1100 mm
Typical local abundance: Rare.
Vegetation: Amongst *Rubus discolor*.
Substrate: Alluvial soil from sandstone, fertile.
Exposure:

Conservation

Conservation: Probably unlikely to become a major weed.

Melodinus australis

APOCYNACEAE

Southern Melodinus

Life history

Growth form: Tall woody climber with twining stems, milky latex, and yellow flowers.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Summer–autumn.

Fruit/seed: Fruit: orange berry, 4–5 cm long with seeds embedded in pulp.

Dispersal, establishment & growth: Diaspore: berry, probably bird-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Coast, Gosford to Illawarra.

Select locations: Gosford, Mt Avoca, Bola Creek, Mt Keira, Mt Kembla, Dapto West (southern limit).

Habitat

Habitat: Gullies.

Altitude: 0–100 m

Annual rainfall: above 1600 mm

Typical local abundance: Frequent.

Vegetation: Warm temperate rainforest.

Substrate: High nutrient soils. Clay soils from ? alluvium, soil fertile.

Exposure:

Conservation

Conservation: Rare, southern limit Mt Kembla. Conservation status unknown.

Nerium oleander *

APOCYNACEAE

Oleander

Life history

Growth form: Shrub to 4 m high with watery sap.

Vegetative spread: Recorded suckering from roots at Ingleside (L. Schaeper pers. comm.)

Longevity: ? 30–40 years.

Primary juvenile period:

Flowers: Pink, reddish or white, November–April.

Fruit/seed: Fruit: follicles 8–15 cm long, 5–10 mm wide; seeds numerous, tufted.

Dispersal, establishment & growth: Diaspore: seed, wind and probably water-dispersed.

Fire response:

Interaction with other organisms: Reports of accidental poisoning of humans and stock, causing death (Hurst 1942). Contains digitalis-like glycosides, proved too toxic for medical use, causes increased contractility of heart muscle; all parts toxic to animals, particularly the seeds (Blackwell 1990). Smoke should not be inhaled if plants burnt (Harden 1992). Unpalatable to stock (Everist 1974).

Distribution

Status/origin: Exotic, native to Mediterranean. Cultivated as an ornamental.

Botanical subregions: NC CC NWS.

Distribution Sydney area: Only naturalised record, Deep Creek (Narrabeen 1980); widely planted.

Select locations: Deep Creek (Narrabeen 1980).

Habitat

Habitat: Roadside.

Altitude: 0–40 m

Annual rainfall: above 1200 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Naturalised status not confirmed — often planted in semi-wild sites.

Parsonsia brownii**APOCYNACEAE**

Mountain Silkpod

Life history**Growth form:** Tall climber.**Vegetative spread:** No.**Longevity:****Primary juvenile period:****Flowers:** November–April.**Fruit/seed:** Fruit: capsule 5–10 cm long, separating to release numerous plumed seeds, mature January–April (limited data).**Dispersal, establishment & growth:** Diaspore: plumed seed, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC SC NT CT ST; Vic., Tas.**Distribution Sydney area:** Upper Blue Mountains, Robertson area.**Select locations:** Mt Coricudgy, Mt Wilson, Blackheath, Robertson Nature Reserve, Fitzroy Falls, Kangaroo Valley.**Habitat****Habitat:** Rainforest or moist gullies near waterfalls.**Altitude:** 500–1000 m **Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Warm temperate rainforest e.g. with *Doryphora*.**Substrate:** Basalt soils or enriched sandstone, soil very fertile–fertile. Water table mostly high, moisture supply continuous, fresh.**Exposure:****Conservation****Conservation:** Conservation status unknown.**Parsonsia lanceolata****APOCYNACEAE****Life history****Growth form:** Climber with stems to 4 m high.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** March (one record).**Fruit/seed:** Fruit: capsule 6–12 cm long separating to release numerous plumed seeds. Green capsule recorded in March.**Dispersal, establishment & growth:** Diaspore: plumed seed, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT NWS CWS NWP; Qld.**Distribution Sydney area:** Lansdowne is only record for the Sydney area.**Select locations:** Lansdowne Park, Lansdowne (1992).**Habitat****Habitat:** Woodland.**Altitude:** 50 m **Annual rainfall:** 1000 mm**Typical local abundance:****Vegetation:** Mid strata in Cumberland Plain Woodland e.g. *Eucalyptus moluccana*, *E. tereticornis*.**Substrate:** Clay soil from Wianamatta Shale, fertile. Water table permanently low, moisture supply intermittent, fresh.**Exposure:****Conservation****Conservation:** Only one locality, southern limit, not protected. Relatively large number of old records (outside CC) suggests that species was more common in 1890–1920 period possibly a result of clearing forest and opening up to light. Subsequent rarity suggests grazing and loss of habitat have reduced the relative occurrence.

Parsonsia sp. A (incorr. *P. leichhardtii*)

APOCYNACEAE

Black Silkpod

Life history

Growth form: Twiner to 5 m high, with watery sap.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: February–July.

Fruit/seed: Fruit: capsule 7–10 cm long, separating to release numerous plumed seeds, matures Oct.

Dispersal, establishment & growth: Diaspore: plumed seed, wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT CT.

Distribution Sydney area: Blue Mountains, Illawarra, rare.

Select locations: Mt Wilson, Newnes, Mountian Lagoon, Berambing, Upper Avon Dam.

Habitat

Habitat: Deep gullies.

Altitude: 0–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Occasional–rare.

Vegetation: Warm temperate rainforest e.g. *Ceratopetalum–Doryphora*.

Substrate: Basalt or enriched sandstone, soil very fertile–fertile, fresh.

Exposure:

Conservation

Conservation: Upper Avon Dam — southern limit. Conservation status unknown.

Parsonsia straminea var. straminea

APOCYNACEAE

Common Silkpod

Life history

Growth form: Tall woody vine climbing by adventitious roots and twining stems.

Vegetative spread: No.

Longevity:

Primary juvenile period:

Flowers: November–June, peak February.

Fruit/seed: Fruit: capsule 10–20 cm long, separating to release numerous plumed seeds.

Matures September–December. Seeds dispersed by wind.

Dispersal, establishment & growth: Diaspore: plumed seed, wind dispersed (Westoby *et al.* 1990).

Plants grow vigorously in Autumn.

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT CWS; Qld.

Distribution Sydney area: Coast and eastern edge of Tablelands. Widespread.

Select locations: Catherine Hill Bay, Calga, Narrabeen, Bola Creek, Otford, Albion Park, Cambewarra, Richmond, Mountain Lagoon, Mt Coricudgy, Belmore Falls.

Habitat

Habitat: Levee banks, fertile sites.

Altitude: 0–900 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Rainforest or edges of rainforest, sometimes in floodplain forest.

Substrate: Basalt soil, sometimes sandy soil, very fertile–fertile.

Water table mostly low, moisture supply intermittent, fresh.

Exposure: Sheltered, mid shade.

Conservation

Conservation: Probably adequately conserved.

Vinca major *

APOCYNACEAE

Periwinkle

Life history

Growth form: Trailing herbaceous perennial with blue-purple flower and milky sap.
Vegetative spread: Trailing stems to 1 m long which may root at tips (Auld & Medd 1987).
Longevity:
Primary juvenile period:
Flowers: Spring-summer.
Fruit/seed: Fruit: follicle 5 cm long usually in pairs, seeds not winged.
Dispersal, establishment & growth: Diaspore: seeds ? — also stem segments with roots, dispersed by humans in dumped garden waste.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Mediterranean. Frequently cultivated as an ornamental.
Botanical subregions: NC CC SC NT CT ST SWS SWP; LHI, Vic., Tas.
Distribution Sydney area: Widespread.
Select locations: Douglas Park, Katoomba.

Habitat

Habitat: Disturbed areas, riverbanks.
Altitude: 0-1000 m **Annual rainfall:** above 800 mm
Typical local abundance: Rare-frequent.
Vegetation:
Substrate: Riverbank on sandstone.
Exposure:

Conservation

Conservation: Occasionally naturalised near habitation.

Ilex aquifolium *

AQUIFOLIACEAE

Holly

Life history

Growth form: Shrub or small tree to 10 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Autumn.
Fruit/seed: Bright red drupe, 7-10 mm diam. Fruit weight 0.3 g, 3 seeds per fruit (extra data on seed and pulp characteristics in French 1991).
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe, introduced as ornamental.
Botanical subregions: CT; S.A.
Distribution Sydney area: Occasionally naturalised in Blue Mountains.
Select locations: Mt Wilson (1896, 1929).

Habitat

Habitat: Naturalised on edge of rainforest gullies.
Altitude: 900 m **Annual rainfall:** 1200 mm
Typical local abundance:
Vegetation: Rainforest.
Substrate: Basalt. Very fertile soil.
Exposure:

Conservation

Conservation: Localised exotic, current situation not known.

Astrotricha crassifolia**ARALIACEAE****Life history**

Growth form: Shrub to 2 m high.

Vegetative spread: Capable of root suckering, root connections weak.

Longevity: Probably indefinite.

Primary juvenile period:

Flowers: September–December.

Fruit/seed: Fruit: 2 mericarps, not winged, mature November–December.

Dispersal, establishment & growth:

Fire response: Resprouts from rootstock and root suckers.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC.

Distribution Sydney area: Gosford area and Woronora — rare.

Select locations: Warrah, Mt Wondabyne (Brisbane Water NP), Patonga, Woronora Dam, Hacking River.

Habitat

Habitat: Dry ridgetop.

Altitude: 0–300 m

Annual rainfall: above 1200 mm

Typical local abundance: Rare

Vegetation: Shrubby woodland e.g. with *Hakea*, *Banksia*, *Xylomelum*.

Substrate: Shallow to deep sandy loam from sandstone. Very infertile soil. Water table permanently low, moisture supply intermittent, fresh.

Exposure: In light shade.

Conservation

Conservation: Rare local endemic with restricted distribution and uncommon at these sites, possibly should be on national rare species list. Condition of population on Hacking River, presumably in Royal N.P., not known.

Astrotricha floccosa**ARALIACEAE****Life history**

Growth form: Shrub to 3 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: September–December, peak October.

Fruit/seed: Fruit: 2 mericarps, not winged, mature October–December, peak October.

Dispersal, establishment & growth: Diaspore: seed, seedling recruitment mainly after fire.

Plants, presumably from post fire recruitment, conspicuous 3–5 years after fire.

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC.

Distribution Sydney area: Coast and adjacent plateaus north of Port Jackson, also Casula. Gosford–Port Jackson, Lower Blue Mountains on monocline.

Select locations: Pearl Beach, Patonga, Ku-ring-gai Chase NP, Bayview, Narrabeen, Mosman, Grassy Hill, Hawkesbury Lookout, Springwood.

Habitat

Habitat: Hillsides and often steep rocky slopes.

Altitude: 0–400 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent.

Vegetation: Dry eucalypt forest e.g. with *Eucalyptus umbra*–*E. paniculata*.

Substrate: Sandy loam from sandstone often influenced by Narrabeen Group Shales or Shale lenses. Infertile soil. Water table permanently low, well drained, moisture supply intermittent, fresh.

Exposure: In exposed situations, light shade.

Conservation

Conservation: Local Sydney endemic probably well conserved.

Astrotricha latifolia

ARALIACEAE

Life history

Growth form: Shrub to 3 m high. Forms between *A. floccosa* and *A. latifolia* occur.
Vegetative spread: Probably not.
Longevity: Probably short, less than 10 years.
Primary juvenile period:
Flowers: November–December, peak October.
Fruit/seed: Fruit: 2 mericarps, not winged, mature November–December, peak December.
Dispersal, establishment & growth: Germination possibly associated with soil disturbance, plants reported from road verge disturbed 4–5 years previously.
Fire response: Probably killed.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT; Qld.
Distribution Sydney area: Widespread, coastal sandstone plateaus north of Sydney and lower Blue Mountains and south west.
Select locations: Olney, Patonga, Cheltenham, Kentlyn, Nortons Basin, Kangaroo Valley, Minnamurra Falls, Boorai Creek, Hawkesbury Lookout, Mt Irvine.

Habitat

Habitat: Gullies or lower hillslopes.
Altitude: 0–1000 m **Annual rainfall:** above 900 m
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest. Moist eucalypt forest e.g. with *Syncarpia glomulifera*, *Eucalyptus saligna*, *E. pilularis*, sometimes in rainforest.
Substrate: Colluvial sandy soils on sandstone, basalt or shale, very fertile–infertile soil.
Water table: mostly low, moisture supply intermittent, fresh.
Exposure: In sheltered situations, mid–light shade.

Conservation

Conservation: Conservation status unknown.

Astrotricha ledifolia

ARALIACEAE

Life history

Growth form: Shrub 1–2 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: November–December, peak November.
Fruit/seed: Fruit: 2 mericarps, not winged, mature November–January, peak November.
Dispersal, establishment & growth: Germination possibly associated with soil disturbance.
Fire response: Regrowth only from surviving rootstocks, no seedlings recorded less than 1 year after fire (Purdie 1977).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST; Vic.
Distribution Sydney area: Upper Blue Mountains, Bathurst area, Wingello, rare.
Select locations: West of Bell, Clarence, Sunny Corner, between Bathurst and Orange, Wombeyan Caves, Wingello.

Habitat

Habitat: Stony soils, sometimes disturbed ground e.g. edge of road cutting.
Altitude: above 700 m **Annual rainfall:** above 1000 mm
Typical local abundance: Occasional.
Vegetation: Eucalypt open-forest.
Substrate: Stony or sandy soil, or deep loam, sometimes from sandstones. Soil fertile–infertile.
Water table: mostly low, moisture supply intermittent, fresh.
Exposure: Exposed situations in light–no shade.

Conservation

Conservation: Rare in the area, northern limit Clarence.
 Conservation status unknown.

Astrotricha linearis**ARALIACEAE****Life history****Growth form:** Shrub to 1.5 m high, branchlets covered with a close indumentum.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** October–December.**Fruit/seed:** Fruit: 2 mericarps, not winged.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** SC CT ST CWS: Vic.**Distribution Sydney area:****Select locations:** North from Bathurst (1822).**Habitat****Habitat:****Altitude:** 0–800 m**Annual rainfall:** above 900 mm**Typical local abundance:****Vegetation:** Heath, dry eucalypt woodland.**Substrate:** Sandstone.**Exposure:****Conservation****Conservation:** Only record for Sydney area is an early collection by Allan Cunningham.**Astrotricha longifolia** (inland form)**ARALIACEAE****Life history****Growth form:** Shrub to 3 m high.**Vegetative spread:** No.**Longevity:** Indefinite.**Primary juvenile period:****Flowers:** November–January.**Fruit/seed:** Fruit: 2 mericarps, not winged.**Dispersal, establishment & growth:****Fire response:** Probably resprouts at ground level or below.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NT CT ST NWS NWP SWP; Qld.**Distribution Sydney area:** Upper Blue Mountains; populations intermediate between inland and coastal forms occur in northern Sydney e.g. Galston Gorge and lower Blue Mountains (Harden 1992)**Select locations:** Newnes Plateau, Bell–Lithgow Road, Burratorang Lookout, Hilltop.**Habitat****Habitat:** Ridgetops or sides of valleys.**Altitude:** 600–1100 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Eucalypt open-forest e.g. with *Eucalyptus macrorhyncha* or moister conditions with *Callicoma* thickets.**Substrate:** Gullies on sandstone. Stony loam to sandy clay from sandstone, soil infertile.**Water table mostly low, moisture supply possibly continuous, fresh.****Exposure:** In sheltered situations.**Conservation****Conservation:** Conservation status unknown.

Astrotricha obovata (A. sp. A)**ARALIACEAE****Life history**

Growth form: Erect to spreading shrub 0.6–1.0 m high, suckering from base.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: November–December.

Fruit/seed: Fruit: 2 mericarps, not winged, matures December.

Dispersal, establishment & growth: Recorded from disturbed sites near roads.

Fire response: Probably resprouts.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC.

Distribution Sydney area: Northern Blue Mountains.

Select locations: Howes Valley, Gaspers Mtn, Colo Heights, Putty, Bucketty, Mogo Creek, Kulnura.

Habitat

Habitat: Sandy soil sometimes disturbed sites.

Altitude: 0–700 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent–occasional.

Vegetation: Dry Eucalypt woodland e.g. with *Angophora costata*, *A. bakeri*.

Substrate: Sandy soil from sandstone. Sometimes rocky slope. Very infertile soil.

Water table permanently low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Probably adequately conserved. Southern limit Colo Heights.

Cephalalaria cephalobotrys**ARALIACEAE**

Climbing Panax

Life history

Growth form: Climber, often quite tall or scrambling shrub.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: March.

Fruit/seed: Fruit: succulent, black drupe, 5 mm diameter, matures May–July.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT; Qld.

Distribution Sydney area: Mainly coast, rare.

Select locations: Mt Coricudgy, Mountain Lagoon, Gosford, Bulli, Macquarie Pass, Barren Grounds, Minnamurra Falls.

Habitat

Habitat:

Altitude: 0–1100 m

Annual rainfall: above 1100 mm

Typical local abundance: Rare.

Vegetation: Warm temperate rainforest e.g. with *Doryphora*.

Substrate: Basalt or talus slope, soil very fertile–fertile. Water table mostly high, moisture supply intermittent, fresh.

Exposure: In mid shade.

Conservation

Conservation: Rare, conservation status unknown.

Hedera helix ***ARALIACEAE**

English Ivy

Life history**Growth form:** Woody climber or creeper to 20 m with aerial roots along stem.**Vegetative spread:** Capable of rooting from stems and spreading.**Longevity:** Indefinite.**Primary juvenile period:****Flowers:** December–March. February–March (Price 1963).**Fruit/seed:** Fruit 5–10 mm diam, dull to black, matures June–September.**Dispersal, establishment & growth:** Diaspore: fruit, recorded in regurgitated pellets of Pied Currawong (Buchanan 1989).**Fire response:****Interaction with other organisms:** Fruit reported from pellets of Currawongs (Buchanan 1989).

Leaves and fruit poisonous if eaten.

Distribution**Status/origin:** Exotic, native to Europe & N Africa. Introduced as an ornamental.**Botanical subregions:** SC NT CT ST; Vic.**Distribution Sydney area:** Occasionally naturalised, usually near habitation.**Select locations:** Wolgan Gap, Mt Wilson (1949), Robertson, Barrengarry Mountain.**Habitat****Habitat:** Disturbed sites, usually near habitation.**Altitude:** 0–1000 m**Annual rainfall:** above 900 mm**Typical local abundance:** Frequent.**Vegetation:** Disturbed areas of rainforest of *Doryphora sassafras*.**Substrate:** Sandstone, basalt soils, fertile–infertile.**Exposure:****Conservation****Conservation:** Minor bushland weed.**Polyscias elegans****ARALIACEAE**

Celery Wood, Silver Basswood

Life history**Growth form:** Tree to 30 m high with a trichotomously branched crown (Floyd 1982), sparingly branched, leaflets aromatic with odour of celery when crushed.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** Purple, not scented, April–August.**Fruit/seed:** Fruit: purple-black succulent berry, 7 mm diameter containing 2 seeds. Matures April–June.**Dispersal, establishment & growth:** Diaspore: berry, probably bird-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC; Qld, NG.**Distribution Sydney area:** Coastal Illawarra, north from Jervis Bay.**Select locations:** Werong Beach, Otford, Albion Park, Bass Point, Minnamurra Falls.**Habitat****Habitat:** Littoral rainforest.**Altitude:** 0–200 m**Annual rainfall:** above 1400 mm**Typical local abundance:** Rare.**Vegetation:** Littoral rainforest e.g. with *Acmena smithii*, *Cassine australis*, *Livistona australis*.**Substrate:** Clay soil from shale strata, marine sands, fertile. On volcanic soils where it develops best but also on poorer sedimentary soils (Floyd 1982). Water table mostly low, moisture supply intermittent, fresh.**Exposure:****Conservation****Conservation:** Generally uncommon in the area.

Polyscias murrayi

ARALIACEAE

Pencil Cedar, Umbrella Tree

Life history

Growth form: Tree to 24 m high, sparingly branched on upper trunk.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: March–April.

Fruit/seed: A succulent berry, 4 mm long, purple-blue when ripe, matures March–June.

Dispersal, establishment & growth: Diaspore: berry, probably bird-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC; Qld, Vic.

Distribution Sydney area: Coast and Lower Blue Mountains.

Select locations: Gosford (Strickland SF), Otford, Macquarie Pass, Jamberoo, Berambing, Bilpin, Woodford.

Habitat

Habitat: Sheltered gullies.

Altitude: 0–500 m

Annual rainfall: above 1100 mm

Typical local abundance: Occasional–rare.

Vegetation: Warm temperate rainforest e.g. Coachwood, *Sassafras*, *Acmena*, disturbed rainforest.

Substrate: Colluvial or alluvial sandy soil in gullies, fertile. Non-saline.

Exposure: Sheltered situations.

Conservation

Conservation: Conservation status unknown.

Polyscias sambucifolia

ARALIACEAE

Elderberry Panax

Life history

Growth form: Shrub 1–3 m high. 3 subspecies described in Flora of NSW Vol. 3 (Harden 1992), all recorded for Sydney area.

Vegetative spread: Limited vegetative spread possible by root suckers, perhaps 2–3 m.

Longevity: Indefinite.

Primary juvenile period:

Flowers: December–February.

Fruit/seed: Succulent drupe 4 mm long, steely blue when ripe. Mature January–February. Fruit weight 0.114 g, 2 seeds per fruit (extra data on seed and pulp characteristics in French 1991).

Dispersal, establishment & growth: Diaspore: fruit. Dispersal — vertebrate-adapted (Westoby *et al.* 1990), probably bird-dispersed e.g. Currawongs. Commonly grows on disturbed sites and may persist in disturbed urban bushland. Generally survives cutting at ground level.

Fire response: Stems killed and regenerates from basal sprouts and root suckers (Fox 1988).

Interaction with other organisms: Fruit reported from regurgitated pellets of Currawongs (Buchanan 1989). Foodplant of moth caterpillar *Cryptoptila australana* (Coupar 1992).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Qld, Vic., Tas*.

Distribution Sydney area: Widespread, Coast and Blue Mountains.

Select locations: Gosford, Narrabeen, Neilsen Park, Liverpool, Mt Coricudgy, Buralow Creek, Clarence, Colo Vale, Mt Flora, Bundanoon Creek.

Habitat

Habitat: Forest.

Altitude: 0–1000 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent–occasional.

Vegetation: Tall open-forest and open-forest, in or on the margins of rainforest.

Substrate: Usually on heavier soils or in gullies.

Exposure: Sheltered, mid-shade.

Conservation

Conservation: Probably adequate overall, though vulnerable in Western Sydney (Benson & McDougall 1991).

Tetrapanax papyrifer ***ARALIACEAE**

Rice Paper Plant

Life history**Growth form:** Shrub to 4 m high.**Vegetative spread:** Readily suckers from stolons to form clumps.**Longevity:** Indefinite.**Primary juvenile period:****Flowers:** May–June (Price 1963).**Fruit/seed:** Drupe.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:** Stem pith used in Asia for making rice-paper.**Distribution****Status/origin:** Exotic, native to E Asia, introduced as an ornamental.**Botanical subregions:** CC ?CT.**Distribution Sydney area:** Sporadically naturalised as a garden escape.**Select locations:** Austinmer, Kangaroo Valley (1938).**Habitat****Habitat:** Old gardens.**Altitude:** 0–200 m**Annual rainfall:** above 1200 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Sporadically naturalised as a garden escape but not clear whether spread is by seed or just by stolon.**Araujia sericiflora *** (*A. hortorum*)**ASCLEPIADACEAE**

Moth Plant

Life history**Growth form:** Twiner with milky juice.**Vegetative spread:** No**Longevity:** ?10–20 years.**Primary juvenile period:****Flowers:** December–March, peak January–February.**Fruit/seed:** Fleshy, pear-shaped fruits 5–8 cm long splitting to release numerous seeds, mature April–May. Seeds with an apical tuft of long silky hairs (Hurst 1942).**Dispersal, establishment & growth:** Diaspore: plumed seed dispersed by wind; and possibly water-dispersed (Carr *et al.* 1992).

Readily establishes in moist soil in low light conditions, below-canopy species.

Fire response: Probably killed.**Interaction with other organisms:** Suspected of being poisonous to cattle and poultry (Auld & Medd 1987). Foodplant of butterfly caterpillar *Danaus plexippus* (Coupar 1992). Moths attracted by the scent (phenylacetaldehyde) are occasionally trapped by the proboscis in a slit of the anther and die a lingering death (Common 1990). Seed poisonous to poultry (Hurst 1942).**Distribution****Status/origin:** Exotic, native to Peru. Probably introduced as garden ornamental.**Botanical subregions:** NC CC SC NWS SWP; Qld, Vic.**Distribution Sydney area:** Coast and Cumberland Plain.**Select locations:** Early records Kiama (1908), Windsor (1911), Ashfield (1917), Eastwood, Richmond, Bass Hill, Menangle, Kangaroo Valley, Berry, Nowra.**Habitat****Habitat:** Naturalised climber on fences and shrubs, banks of creeks or rivers, remnant bush or waste land.**Altitude:** 0–200 m**Annual rainfall:** 700–1400 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Rainforest, wet eucalypt open-forest, woodland.**Substrate:** Clay soils, commonly from Wianamatta Shale, floodplains. Soil very fertile–fertile. Water table mostly low, moisture supply intermittent, fresh.**Exposure:** Sheltered, light shade.**Conservation****Conservation:** Increasingly common weed in remnant bushland, particularly in unburnt sites, growing over native shrubs and producing copious amounts of seed.

Asclepias curassavica ***ASCLEPIADACEAE**

Blood Flower

Life history**Growth form:** Perennial herb to 1 m high.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** Red and orange-yellow, February–April.**Fruit/seed:** Fruit: follicle 6–9 cm long, matures April, releasing numerous plumed seeds.

Seeds 5–6 mm long (Hurst 1942).

Dispersal, establishment & growth: Diaspore: plumed seed, wind-dispersed.**Fire response:****Interaction with other organisms:** Food-plant for Wanderer Butterfly (Clyne 1990).

Poisonous to guinea pigs, sheep and cattle (Hurst 1942).

Distribution**Status/origin:** Exotic, native to Central America. Garden escape.**Botanical subregions:** NC CC; Qld, S.A., W.A.**Distribution Sydney area:** Suburban area.**Select locations:** Peakhurst (1966), Balmain (1974).**Habitat****Habitat:** Neglected garden, paddock.**Altitude:** 0–100 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Rare.**Vegetation:** Neglected garden, paddock.**Substrate:** Clay soil from Wianamatta Shale. Soil fertile, non-saline.**Exposure:****Conservation****Conservation:** Rarely naturalised in Sydney area.**Cynanchum elegans****ASCLEPIADACEAE****Life history****Growth form:** Glabrous climber with cork-woody bark.**Vegetative spread:** Resprouts from rootstock after cutting (NPWS 1992) but the extent of any spread is unknown.**Longevity:** Probably long-lived.**Primary juvenile period:****Flowers:** August–February.**Fruit/seed:** Fruit: pointed follicle 4–6 cm long with up to 25 seeds.

Seeds 6 mm long with tuft of hair at one end, mature December–May.

Dispersal, establishment & growth: Diaspore: seed, probably wind-dispersed.**Fire response:** Not known, but may resprout.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC CWS.**Distribution Sydney area:** Cobbitty–Jamberoo.**Select locations:** Native Vineyard (Cobbitty), Razorback, Charcoal Creek (Wollongong), Berkely Hills, Mt Keira, Balgownie, West Dapto, Jamberoo.**Habitat****Habitat:** Dry rainforest.**Altitude:** 0–200 m**Annual rainfall:** above 700 mm**Typical local abundance:** Occasional — range from 1–28 individuals per site in Illawarra (NPWS 1992).**Vegetation:** Dry vine-thicket or dry rainforest e.g. with *Streblus brunonianus*, *Guioa semiglauc*.**Substrate:** Shale amphitheatre (Cobbitty). Skeletal clay loam on volcanics (Illawarra). Fertile soil.

Water table mostly low, moisture supply intermittent, fresh.

Exposure: No shade.**Conservation****Conservation:** Coded 2ECi by Briggs & Leigh (1988).

Regarded as locally extinct (Benson & McDougall 1991) but rediscovered at Cobbitty (NPWS 1992).

Recently discovered at Wollongong (NPWS 1992). Threatened by urban development and grazing.

Gomphocarpus fruticosus * (*Asclepias fruticosa*) ASCLEPIADACEAE

Narrow-leaved Cotton Bush

Life history**Growth form:** Shrub 0.3–2 m high, branches pubescent.**Vegetative spread:** No.**Longevity:****Primary juvenile period:****Flowers:** White, August–February.**Fruit/seed:** Fruit: large inflated follicle covered with soft green spines, splitting to release plumed seeds in February–December.**Dispersal, establishment & growth:** Diaspore: seed. Wind dispersed, possibly also water dispersed.**Fire response:****Interaction with other organisms:** Food-plant for caterpillars of Wanderer Butterfly (Clyne 1990).

Poisonous to guinea pigs and sheep but unpalatable (Hurst 1942).

Distribution

Status/origin: Exotic, native to South Africa. Introduced to Sydney before 1844 as an unsuccessful source of 'cotton'. Allan Cunningham reported in his diary on 12.1.1816 '*Gomphocarpus fruticosus* introduced into this Colony, many years ago, is now becoming a pest to the farmer, over running his lands, to a very considerable extent'. It grew wild in 'great quantities' at Homebush and by the roadsides around Sydney (Meredith 1844). Now relatively uncommon, could its original abundance here have been reduced by the introduction of the Wanderer Butterfly in the nineteenth century? (D. Benson).

Botanical subregions: NC CC SC CT NWS CWS; Qld, Vic., S.A., W.A.**Distribution Sydney area:** Widespread.**Select locations:** Yengo Ck, Calga, Grose Vale (1912), Luddenham, Machins Crater, Glenbrook, Lane Cove NP, Ku-ring-gai Chase NP, Kurnell, Faulconbridge, Campbelltown, Macquarie Pass, Wombeyan Caves.**Habitat****Habitat:** Various, cleared weedy sites, roadside.**Altitude:** 0–800 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Woodland, open-forest, cleared weedy sites, behind saltmarsh.**Substrate:** Various soils from sandstone, shale, volcanic necks. Soil fertile–infertile, water table mostly low–permanently low, moisture supply intermittent, fresh.**Exposure:** Shade: light–none.**Conservation****Conservation:** Naturalised weed of cultivated sites, not invasive of bush.

Gomphocarpus physocarpus ***ASCLEPIADACEAE**

Balloon Cotton Bush

Life history**Growth form:** Shrub 0.5–2 m high.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** White, December–May.**Fruit/seed:** Fruit: large inflated follicle covered with soft green spines and splitting to release plumed seeds in December–January.**Dispersal, establishment & growth:** Diaspore: seed, wind-dispersed.**Fire response:****Interaction with other organisms:** Possibly hybridizes with *G. fruticosus* (Harden 1992)

Food-plant for caterpillars of Wanderer Butterfly (Clyne 1990). Poisonous to sheep and cattle (Hurst 1942), but unpalatable and rarely grazed.

Distribution**Status/origin:** Exotic, native to S Africa. Occasionally naturalised.**Botanical subregions:** NC CC CWS; Qld, S.A.**Distribution Sydney area:** Widespread.**Select locations:** Goulburn River, Woy Woy (1912), Ku-ring-gai Chase NP, Georges River (1910), Casula, Menangle.**Habitat****Habitat:** Roadsides, waste places and pastures.**Altitude:** 0–100 m**Annual rainfall:** Above 600 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Occasionally naturalised exotic.**Marsdenia flavescens****ASCLEPIADACEAE**

Hairy Milk Vine

Life history**Growth form:** Tall twiner with slightly yellowish, milky latex.**Vegetative spread:** No.**Longevity:** Probably about 10–50 years.**Primary juvenile period:****Flowers:** December–February.**Fruit/seed:** Fruit is a narrow follicle 4–6 cm long, splitting to release plumed seeds in May.**Dispersal, establishment & growth:** Diaspore: plumed seed, wind-dispersed (Westoby *et al.* 1990).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT; Qld, Vic.**Distribution Sydney area:** Coast Western Blue Mountains.**Select locations:** Razorback, Albion Park, Macquarie Pass, Cambewarra, Kanangra.**Habitat****Habitat:** Rocky sheltered sites.**Altitude:** 0–1000 m**Annual rainfall:** 700–1200 mm**Typical local abundance:** Occasional.**Vegetation:** In vine thicket and dry rainforest.**Substrate:** Sandstone, possibly limestone. Soil fertile. Water table mostly low, moisture supply intermittent, fresh.**Exposure:** Sheltered situations; mid shade.**Conservation****Conservation:** Vulnerable in Western Sydney (Benson & McDougall 1991).

Conservation status elsewhere unknown.

Marsdenia rostrata**ASCLEPIADACEAE**

Common Milk Vine

Life history**Growth form:** Robust twiner with copious milky latex.**Vegetative spread:** No.**Longevity:****Primary juvenile period:****Flowers:** October–January.**Fruit/seed:** Fruit is a broad pointed follicle about 5 cm long, splitting to release plumed seeds.**Dispersal, establishment & growth:** Diaspore: seed, wind-dispersed.**Fire response:****Interaction with other organisms:** Poisonous to pigs, sheep and cattle but unpalatable when fresh; leaves toxic when dry or fresh (Hurst 1942).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST CWS; LHI, Qld, Vic.**Distribution Sydney area:** Most common along coast.**Select locations:** Kincumber, Collaroy, Cobbitty, Razorback, Albion Park, Bass Point, Fitzroy Falls, Saddleback, Glen Alice.**Habitat****Habitat:** Sheltered gullies.**Altitude:** 0–800 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent.**Vegetation:** Rainforest either *Doryphora-Cenatopetalum* or drier with *Streblus*, *Notelaea*.

Near the sea in sheltered places.

Substrate: Deep sandy soils, generally from sandstone, fertile–infertile. Non-saline.**Exposure:** Sheltered situations; mid shade.**Conservation****Conservation:** Vulnerable in Western Sydney (Benson & McDougall 1991).**Marsdenia suaveolens****ASCLEPIADACEAE**

Scented Marsdenia

Life history**Growth form:** Variable in habit, twining when in forests, often a small shrub when in heath.**Vegetative spread:** No.**Longevity:****Primary juvenile period:****Flowers:** October–February, peak December.**Fruit/seed:** Fruit is a pointed follicle 5–10 cm long, splitting to release plumed seeds in August–January.**Dispersal, establishment & growth:** Diaspore: seed, wind-dispersed.**Fire response:** Resprouts. Plants 20 cm high fruiting prolifically 5 months after very high intensity fire in Bantry Bay (June 1991, L.McD.).**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC CT.**Distribution Sydney area:** Widespread on sandstone plateaus.**Select locations:** Cowan Creek, Beecroft, Kentlyn, Woronora River, Culboul Range, Mountain Lagoon, Mulgoa, Bargo, Currant Mountain Gap, Wentworth Falls, Bundanoon.**Habitat****Habitat:** Sandstone gullies.**Altitude:** 0–1000 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Moist eucalypt forest e.g. with *Eucalyptus pilularis*, *Syncarpia glomulifera*, *Eucalyptus piperita*.**Substrate:** Sandy alluvial soil from sandstone, infertile. Water table mostly low, moisture supply intermittent, fresh.**Exposure:** Sheltered situations; mid shade.**Conservation****Conservation:** Conserved in Western Sydney (Benson & McDougall 1991). Probably adequately conserved.

Marsdenia viridiflora (Leichhardtia leptophylla) ASCLEPIADACEAE

Native Pear

Life history

Growth form: Woody twiner with potato-like tuber up to 10 cm diameter.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: November.
Fruit/seed: Fruit: ovoid follicle 4–8 cm long, splitting to release plumed seeds. Mature in Autumn.
Dispersal, establishment & growth: Diaspore: plumed seed, wind-dispersed.
Fire response: May resprout.
Interaction with other organisms: Aborigines ate immature fruit (baked) and tubers.

Distribution

Status/origin: Native.
Botanical subregions: CC NWS CWS; Qld.
Distribution Sydney area: Western Sydney, particularly Fairfield area, rare.
Select locations: Chester Hill, Villawood, Smithfield, Lansdowne Park, Rooty Hill (1914), Razorback southern limit.

Habitat

Habitat: Open areas in remnant shale woodland.
Altitude: 0–100 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Rare.
Vegetation: *Themeda* grassland with e.g. *Eucalyptus tereticornis*, *Bursaria spinosa*, *Themeda*.
Substrate: Gravelly shale, fertile soil from Wianamatta Shale. Water table permanently low, moisture supply intermittent, fresh.
Exposure: No shade.

Conservation

Conservation: Rare species needing protection.
Vulnerable in Western Sydney (Benson & McDougall 1991). All Cumberland Plain sites now lost except Lansdowne and perhaps Razorback. Should probably be on rare and endangered list.

Tweedia coerulea * (Oxypetalum coeruleum) ASCLEPIADACEAE

Life history

Growth form: Stiff herb or subshrub to 1 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers:
Fruit/seed: Fruit: follicle 9–13 cm long with plumed seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to America, introduced as an ornamental.
Botanical subregions: NC CC SC NT NWS CWS SWS; Qld.
Distribution Sydney area: Grown as an ornamental, sometimes naturalised.
Select locations: Limited data, no specimens found in Herbarium.

Habitat

Habitat:
Altitude: **Annual rainfall:**
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Impact unknown.

Tylophora barbata

ASCLEPIADACEAE

Bearded Tylophora

Life history

Growth form: Slender woody climber.

Vegetative spread: No.

Longevity:

Primary juvenile period:

Flowers: September–May. November–February (Forster 1992).

Fruit/seed: Fruit: slender follicle 5–7 cm long, rarely seen, seeds plumed. Matures March.

Seed 5–7 mm long, c. 3 mm wide; coma c. 25 mm long (Forster 1992).

Dispersal, establishment & growth: Diaspore: seed, wind-dispersed (Westoby *et al.* 1990).

Fire response: Probably resprouts.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST; Vic.

Distribution Sydney area: Restricted to coastal areas (Forster 1992).

Select locations: Lovetts Bay, Homebush Bay, Ingleburn, Douglas Park, Mt Kembla, Shellharbour, Kangaroo Valley, Mt Coricudgy, Mt Tomah, Wildes Meadow.

Habitat

Habitat: Sheltered moist gullies.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Moist open-forest e.g. with *Syncarpia glomulifera* and rainforest.

Substrate: Sandy loam from shale-enriched sandstone or clayey soil from breccia and basalt, skeletal soil from slate, very fertile–fertile. Water table mostly low, moisture supply intermittent, fresh.

Exposure: Mid–light shade.

Conservation

Conservation: Probably well-conserved. Conserved in Western Sydney (Benson & McDougall 1991).

Commonly encountered — not rare, endangered or threatened at this stage (Forster 1992).

Tylophora woollsii

ASCLEPIADACEAE

Life history

Growth form: Slender woody climber.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Probably April. Flowers have been recorded in March (Forster 1992).

Fruit/seed: Fruit slender follicle to 7.5 cm long, with plumed seeds. Seed c. 7 mm long, 2 mm wide; coma c. 1 cm long (Forster 1992).

Dispersal, establishment & growth: Diaspore: seed, wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC.

Distribution Sydney area: Known from only two collections. ‘Parramatta’ collected in the 1860’s and Clouds Creek near Dorriggo in 1964 (outside Sydney area) (Leigh, Boden & Briggs 1984).

Select locations: Only collection in area is TYPE collection from Parramatta by William Woolls (1869).

Habitat

Habitat: Probably moist eucalypt forest.

Altitude: 0–100 m

Annual rainfall:

Typical local abundance:

Vegetation: Probably moist eucalypt forest. Rainforest margins (Forster 1992).

Substrate: Probably fertile, shale soils.

Exposure:

Conservation

Conservation: An extremely rare plant coded 2E– by Briggs & Leigh (1988). Now extinct at Parramatta and probably elsewhere in Western Sydney (Benson & McDougall 1991). Now restricted to north-eastern NSW; suggested coding 3E, an exceptionally rare plant (Forster 1992).

References

- Adam, P.A. (1981) Saltmarsh plants of New South Wales. *Wetlands (Australia)* 1(1): 11-19.
- Affolter, J.M. (1985). A monograph of the Genus *Liliopsis* (Umbelliferae) *Systematic Botany Monographs* 6: 121-127.
- Anon (1991) Appendix 10. In *Plant invasions: the incidence of environmental weeds in Australia. Kowari 2* (Australian National Parks and Wildlife Service: Canberra).
- Auld, B.A. & Medd, R.W. (1987) *Weeds: an illustrated guide to the weeds of Australia* (Inkata Press: Sydney).
- Barker, R.M. (1986) A taxonomic revision of Australian Acanthaceae. *Journal Adelaide Botanic Gardens* 9: 1-286.
- Beadle, N.C.W. (1972) *Students flora of north eastern New South Wales* (Parts 1-6) (University of New England: Armidale).
- Beadle, N.C.W., Evans, O.D., Carolin, R.C. & Tindale, Mary D. (1982) *Flora of the Sydney Region. Third Edition* (Reed: Frenchs Forest).
- Benson, D.H. (1981) Vegetation at Agnes Banks sand deposit, Richmond, New South Wales. *Cunninghamia* 1(1): 35-57.
- Benson, D.H. (1985) Maturation periods for fire-sensitive shrub species in Hawkesbury Sandstone vegetation. *Cunninghamia* 1(3): 339-349.
- Benson, D.H. (1991) Ecology of Sydney plants project. *Cunninghamia* 2(3): 499-500.
- Benson, D.H. & McDougall, L. (1991) *Rare bushland plants of western Sydney* (Royal Botanic Gardens: Sydney).
- Blackwell, W. H. (1990) *Poisonous and medicinal plants* (Prentice Hall: New Jersey).
- Bostock, Peter D. (1992) The circumscription of *Adiantum diaphanum* Blume (Adiantaceae), the filmy maidenhair fern. *Austrobaileya* 3: 661-664.
- Bradley, E. (1972) *Fires in Mosman bushland* (E. & J. Bradley: Mosman).
- Bradstock, R. (1981) Our phoenix flora. *Australian Natural History* 20: 223-226.
- Briggs, J.D. & Leigh, J.H. (1988) *Rare or Threatened Australian Plants*. Special publication No. 14 (Australian National Parks and Wildlife Service: Canberra).
- Buchanan, R. (1989) Pied Currawongs (*Strepera graculina*): their diet and role in weed dispersal in suburban Sydney, New South Wales. *Proceedings of Linnean Society of New South Wales* 111: 241-255.
- Bureau of Meteorology (1975) *Climatic averages: New South Wales* (AGPS: Canberra).
- Bureau of Meteorology (1975) *Climatic survey: Sydney region 5 New South Wales*. (AGPS: Canberra).
- Carr, G.W., Yugovic, J.V. & Robinson, K.E. (1992) *Environmental weed invasions in Victoria: conservation and management implications* (Dept. of Conservation & Environment: East Melbourne).
- Chesterfield, E.A., Taylor, S.J. & Molnar, C.D. (1990) Recovery after wildfire: warm temperate rainforest at Jones Creek. Arthur Rylah Institute for Environmental Research, *Technical Report Series* No. 101.
- Chinnock, R.J. (1993) Notes on *Isoetes* and *Tmesipteris* in Victoria. *Muelleria* 8: 57-60.
- Clarke, P.J. (1989) Coastal plants of New South Wales. *Technical report* No. 22 (Soil Conservation Service of NSW: Sydney).
- Clarke, P.J. & Benson, D.H. (1987) *Vegetation Survey of Lane Cove River State Recreation Area* (Royal Botanic Gardens: Sydney).
- Clemens, J. & Franklin, M.H. (1980) A description of coastal heath at North Head, Sydney Harbour National Park: Impact of recreation and other disturbance since 1951. *Australian Journal Botany* 28: 463-478.

- Clyne, D. (1990) *How to attract butterflies to your garden* (Reed: Balgowlah).
- Common, I.F.B. (1990) *Moths of Australia* (Melbourne University Press: Collingwood).
- Cook, C.D.K. (1990) *Aquatic plant book* (SPB Academic: The Hague).
- Coupar, P. & Coupar, M. (1992) *Flying colours, common caterpillars, butterflies and moths of south-eastern Australia* (New South Wales University Press: Kensington).
- Cribb, A.B. & Cribb, J.W. (1981) *Useful wild plants in Australia* (Collins: Sydney).
- Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. & Leigh, J.H. (1981) *Plants of western New South Wales* (Government Printer: Sydney).
- Dallimore, W. & Jackson, A. (1966) *A handbook of Coniferae and Ginkgoaceae*. Revised by S.G. Harrison (Edward Arnold: London).
- Duncan, D.B. & Isaac, G. (1986) *Ferns and allied plants of Victoria, Tasmania and South Australia* (Melbourne University Press: Melbourne).
- Everist, S.L. (1974) *Poisonous plants of Australia* (Angus and Robertson: Sydney).
- Fairley, A. & Moore, P. (1989) *Native plants of the Sydney district: an identification guide* (Kangaroo Press: Kenthurst).
- Floyd, A.G. (1982) N.S.W. rainforest trees: part X1. *Forestry Commission of New South Wales Research Note No. 48*.
- Forster, P. I. (1992) A taxonomic revision of *Tylophora* R.Br. (Asclepiadaceae: Marsdenieae) in Australia. *Australian Systematic Botany* 5: 29–51.
- Fox, M.D. (1988) Understorey changes following fire at Myall Lakes, New South Wales. *Cunninghamia* 2(1): 85–95.
- French, K. (1991) Characteristics and abundance of vertebrate-dispersed fruits in temperate wet sclerophyll forest in south eastern Australia. *Australian Journal of Ecology* 16: 1–13.
- Gill, A.M. (1975) Fire and the Australian flora: a review. *Australian Forestry* 38: 4–25.
- Gill, A.M. (1981) Adaptive responses of Australian vascular plant species to fires. Chapter 11 in *Fire and the Australian biota* (A.M. Gill, R.H. Groves, I.R. Noble Eds.) (Australian Academy of Science, Canberra).
- Gill, A.M. & Bradstock, R.A. (1992) A national register for the fire responses of plant species. *Cunninghamia* 2(4): 653–660.
- Griffiths, N. (1989) Alligator Weed. Division of Plant Industries. *Agfact* P7.6.46 (NSW Agriculture: Sydney).
- Harden, G.J. (Ed.) (1990–3) *Flora of New South Wales* Vol. 1–4 (New South Wales University Press: Kensington).
- Hurst, E. (1942) *The poison plants of New South Wales* (The poison plants committee of University of Sydney and the New South Wales Department of Agriculture).
- Jarman, S.J., Kantvilas, G. & Brown, M.J. (1986) The ecology of pteridophytes in Tasmanian cool temperate rainforest. *The Fern Gazette* 13: 77–86 (British Pteridological Society: London).
- Jones, D. & Elliot, R. (1986) *Pests, diseases and ailments of Australian plants* (Lothian: Port Melbourne).
- Jones, D. L. (1987) *Encyclopaedia of ferns* (Lothian: Sydney).
- Jones, D. L. (1993) A new species of *Marsilea* L. (Marsileaceae) from Australia. *Muelleria* 8: 65–67.
- Jones, D.L. & Clemesha, S.C. (1981) *Australian ferns and fern allies* (Reed: Sydney).
- Kodala, P.G., James, T.A., Coveny, R.G. & Hind, P.D. (1992) *Reconnaissance survey of the vegetation at Long Swamp, near Penrose, Central Tablelands, NSW* (Royal Botanic Gardens Sydney, unpub.).
- Langkamp, P.J. (Ed.) (1987) *Germination of Australian native plant seed* (Inkata: Melbourne).
- Large, M.F. & Braggins, J.E. (1991) Spore atlas of New Zealand ferns and fern allies. *New Zealand Journal of Botany* supplement.

- Leigh, J., Boden, R. & Briggs, J. (1984) *Extinct and endangered plants of Australia* (Macmillan: South Melbourne).
- Leigh, J.H. & Briggs, J.D. (Eds) (1992) *Threatened Australian Plants: overview and case studies* (Australian National Parks and Wildlife Service: Canberra).
- Leigh, J.H. & Holgate, M.D. (1979) The responses of understorey species of forests and woodlands of the Southern Tablelands to grazing and burning. *Australian Journal of Ecology* 4: 25–45.
- Leishman, M.R., Hughes, L., French, C., Armstrong, D. & Westoby, M. (1992) Seed and seedling biology in relation to modelling vegetation dynamics under global change. *Australian Journal of Botany* 40: 599–613.
- Low, T. (1990) *Bush medicine, a pharmacopoeia of natural remedies* (Angus and Robertson: Sydney).
- Loyal, D.S., Gollen, A.K. & Ratra, R. (1982) Morphological and cytotaxonomic observations on *Azolla pinnata*. *The Fern Gazette* 12: 230–232 (British Pteridological Society: London).
- Maiden, J.H. (1889) *The useful plants of Australia*. Facsimile edition (1975) (Compendium: Sydney).
- McBarron, E.J. (1983) *Poisonous plants: handbook for farmers and graziers*. Department of Agriculture New South Wales (Inkata Press: Melbourne).
- McKinnell, F.H., Hopkins, E.R. and Fox, J.E.D. (Eds) (1991) *Management of radiata pine in Australia*. Forest management in Australia (Surrey Beatty: Chipping Norton).
- McLoughlin, L. & Rawling, J. (1990) *Making your garden bush friendly: how to recognise and control garden plants which invade Sydney's bushland* (McLoughlin-Rawling: Killara).
- Medeiros, A.C., Loope, L.L., Flynn, T., Anderson, S.J., Cuddihy, L.W. & Wilson, K.A. (1992) Notes on the status of an invasive Australian tree fern (*Cyathea cooperi*) in Hawaiian rain forests. *American Fern Journal* 82: 27–33.
- Meredith, C. (1844) *Notes and sketches of New South Wales* (Facsimile Edition, Penguin: Harmondsworth, 1973).
- Mills, K. (1988) *Conservation of rainforest plant species, Illawarra region of NSW, inventory, assessment and recommendations for management* (NSW National Parks and Wildlife Service: Hurstville).
- Monaghan, N. & McMaugh, J. (1987) *Rhus* — an urban weed. *Agfact* P7.6.41 (NSW Agriculture: Sydney).
- Myerscough, P.J. (1990) Comparative plant ecology and the quest for understanding of Australian plants. *Proceedings of the Linnean Society of NSW* 112: 189–199.
- National Parks and Wildlife Service of NSW (1992) Conservation Research Statement *Cynanchum elegans*. National Parks and Wildlife Service Central Region.
- O'Brien, T.P. (1963) The morphology and growth of *Pteridium aquilinum* var. *esculentum* (Forst.) Kuhn. *Annals of Botany* 27: 253–267.
- Page, C.N. (1982) Field observations on the nectaries of bracken *Pteridium aquilinum*, in Britain. *The Fern Gazette* 12: 233–240 (British Pteridological Society: London).
- Parsons, W.T. (1973) *Noxious weeds of Victoria*. (Inkata Press: Melbourne).
- Payne, R. (1992) A short note of interest from Robert Payne, of Andrews Neil. *National Trust Bush Management Newsletter*, March–July (National Trust: Sydney).
- Price, D. (1963) Calendar of flowering times of some plants of the Sydney district, possibly associated with pollinosis. *Contributions from the National Herbarium of NSW* 3: 171–194.
- Purdie, R.W. (1977) Early stages of regeneration after burning in dry sclerophyll vegetation: 1 Regeneration of the understorey by vegetative means. *Australian Journal of Botany* 25: 21–34.
- Quirk, H. & Chambers, T.C. (1981) Drought tolerance in *Cheilanthes* with special reference to the gametophyte. *The Fern Gazette* 12: 121–129 (British Pteridological Society: London).
- Rice, B. & Westoby, M. (1981) Myremecochory in sclerophyll vegetation of the West Head, New South Wales. *Australian Journal of Ecology* 6: 291–298.
- Rowell, R. J. (1970) *Ornamental plants for Australia* (New South Wales University Press: Kensington).

- Ryan, J. (1982) *Salvinia*. Agfact P7.6.13. (Department of Agriculture New South Wales).
- Sainty, G.R. & Jacobs, S.W.L. (1981) *Waterplants of New South Wales* (Water Resources Commission: Sydney).
- Scholer, H.A. (1974) Geomorphology of New South Wales Coastal Rivers. *University of New South Wales Water Research Laboratory, report No. 139*.
- Shinagawa, T. (1962) Small tubers on the roots of *Adiantum diaphanum*, a preliminary note. *Journal of Japanese Botany* 37: 113–117.
- Shuter, E. & Westoby, M. (1992) Herbivorous arthropods on bracken (*Pteridium aquilinum* (L.) Kunze) in Australia compared with elsewhere. *Australian Journal of Ecology* 17: 329–339.
- Simpfendorfer, K.J. (1975) *An introduction to trees for south eastern Australia* (Inkata Press: Melbourne).
- Smith, J. (1981) The distribution and conservation status of a rare conifer, *Microstrobus fitzgeraldii* (Podocarpaceae). *Cunninghamia* 1: 125–128.
- Smith, J.M.B. (1988) *Prunus* (Amygdalaceae) in New South Wales. *Telopea* 3(2): 145–157.
- Smith, L. (1983) Khaki weed. Agfact P7 .6.24 (NSW Agriculture: Sydney).
- Smith, L.W. & Truonce, R.B. (1990) Horsetail — a new weed threat. *Agnote DPI/12* (NSW Agriculture and Fisheries: Sydney).
- Taylor, J.E. & Thomson, J.A. (1990) Allelopathic activity of frond runoff from *Pteridium esculentum* 203–208 in Bracken biology and management (J.A. Thomson & R.J. Smith Edits) *Australian Institute of Science, occasional publication No. 40*.
- Thomson, J.A., Jackson, M.J. & Bock, I.R. (1982) Contrasting resource utilisation in two Australian species of *Drosophila* Fallen (Diptera) feeding on the Bracken fern *Pteridium Scopoli*. *Journal Australian Entomological Society* 21: 29–30.
- Thomson, J.A. & Smith, R.T. (Edits) (1990). Bracken biology and management. *Australian Institute of Agricultural Science, occasional publication No. 40*.
- Thomson, J.A., Willoughby, C. & Shearer, C.M. (1986) Factors affecting the distribution, abundance and economic status of bracken (*Pteridium esculentum*) in New South Wales. In Bracken ecology, land use and control technology. *The proceedings of the International Conference – Bracken '85*, 109–119 (Eds R.T. Smith & J.A. Taylor) (Parthenon Publishing).
- Tindale, M.D. (1961) Pteridophyta of south eastern Australia. *Contributions from the New South Wales National Herbarium Flora Series* Nos 208–211.
- Tindale, M.D. (1963) Pteridophyta of south eastern Australia: Hymenophyllaceae. *Contributions from the New South Wales National Herbarium* 201.
- Tryon, A. F. & Lugardon, Bernard (1991) *Spores of the Pteridophyta* (Springer-Verlag: New York Inc.).
- Tryon, R. M. & Tryon A. F. (1982) *Ferns and allied plants: with special reference to tropical America* (Springer-Verlag: New York).
- Walker, T.G. & Page, C.N. (1982) *Dictymia brownii* (Polypodiaceae S.S.), an ancient Australian fern. *The Fern Gazette* 12: 197–207 (British Pteridological Society: London).
- Westoby, M., Rice, B. & Howell, J. (1990) Seed size and plant growth form as factors in dispersal spectra. *Ecology* 71: 1307–1315.
- Yen, S. & Myerscough, P.J. (1989a) Co-existence of three species of amphibious plants in relation to spatial and temporal variation: field evidence. *Australian Journal of Ecology* 14: 291–303.
- Yen, S. & Myerscough, P.J. (1989b) Co-existence of three species of amphibious plants in relation to spatial and temporal variation: investigation of plant responses. *Australian Journal of Ecology* 14: 305–318.

Index

Scientific names are in bold type, synonyms or misapplied names are in italics and family names are in upper case. Common names are in roman type.

A

- ACANTHACEAE 344–345
- Acer**
- negundo* * 346
 - pseudoplatanus* * 346
- ACERACEAE 346
- Achyranthes**
- aspera* 354
- Actinotus**
- forsythii* 371
 - gibbonsii* 371
 - helianthi* 372
 - minor* 373
- Adder's Tongue 315
- ADIANTACEAE 265–267
- Adiantum**
- aethiopicum* 265
 - diaphanum* 266
 - formosum* 266
 - hispidulum* var. *hispidulum* 267
 - silvaticum* 267
- Aegopodium**
- podagraria* * 373
- AIZOACEAE 347–353
- Alternanthera**
- angustifolia* 354
 - denticulata* 355
 - nana* 355
 - philoxeroides* * 356
 - pungens* * 357
 - repens* 357
- Alyxia**
- ruscifolia* 394
- Amaranth**
- Dwarf 360
 - Green 363
 - Powell's 361
 - Redroot 362
 - Slim 359
 - South American 361
 - Spreading 358
- AMARANTHACEAE 354–366
- Amaranthus**
- albus* * 357
 - cruentus* * 358
 - deflexus* * 358
 - hybridus* * 359
 - lividus* * 359
 - macrocarpus**
 - var. *macrocarpus* 360
 - var. *pallidus* 360
 - powellii* * 361
 - quitensis* * 361
 - retroflexus* * 362
 - spinosus* * 362
 - viridus* * 363
- Ammi**
- majus* * 374
- AMYGDALACEAE 366–369
- ANACARDIACEAE 369–370
- APIACEAE 371–393
- Apium**
- graveolens* * 374
 - leptophyllum* * 377
 - prostratum* subsp. *prostratum*
 - var. *filiforme* 375
 - var. *prostratum* 375
- APOCYNACEAE 394–398
- Aptenia**
- cordifolia* 347
- AQUIFOLIACEAE 398
- Arachniodes**
- aristata* 294
- ARALIACEAE 399–405
- Araujia**
- hortorum* * 405
 - sericiflora* * 405
- Arthropteris**
- beckleri* 286
 - tenella* 287
- ASCLEPIADACEAE 405–411
- Asclepias**
- curassavica* * 406
 - fruticosa* 407
- ASPLENIACEAE 268–273
- Asplenium**
- aethiopicum* 268
 - attenuatum* 268
 - australasicum* 269
 - bulbiferum* subsp. *gracillimum* 269
 - difforme* 270
 - flabellifolium* 270
 - flaccidum* subsp. *flaccidum* 271
 - obtusatum* 271
 - polyodon* 272
 - trichomanes* subsp. *quadrivalens* 272
- Astrotricha**
- crassifolia* 399
 - floccosa* 399
 - latifolia* 400
 - ledifolia* 400
 - linearis* 401

- longifolia* 401
- obovata* 402
- sp. A* 402
- ATHYRIACEAE 274
- Athyrium*
 - australe* 274
- Austral Lady Fern 274
- Austral Pillwort 313
- Azolla**
 - filiculoides* var. *rubra* 275
 - pinnata* 276
- AZOLLACEAE 275–276

B

- Bat's Wing Fern 289
- Bearded Tylophora 411
- Bird's Nest Fern 269
- Black-eyed Susan 345
- BLECHNACEAE 277–284
- Blechnum**
 - ambiguum* 277
 - camfieldii* 277
 - cartilagineum* 278
 - chambersii* 278
 - gregsonii* 279
 - indicum* 279
 - minus* 280
 - nudum* 281
 - patersonii* 281
 - penna-marina* 282
 - wattsii* 282
- Blood Flower 406
- Blue Devil 380
 - Prostrate 381
- Botrychium**
 - australe* 314
- Box Elder 346
- Bracken 292
 - Hairy 323
- Brake
 - Chinese 335
 - Jungle 335
 - Slender 322
 - Tender 323
- Brunoniella**
 - australis* 344
 - pumilio* 344
- Bupleurum**
 - lancifolium* * 376
 - subovatum* * 376
- Burr
 - Needle 362

C

- Callitris**
 - endlicheri* 339
 - muelleri* 339
 - rhomboidea* 340
- Calochlaena**
 - dubia* 293
- Carpobrotus**
 - edulis* * 347
 - glaucescens* 348
- Carraway
 - Australian 386
- Carrot
 - Native 379
 - Wild 378
- Cedar
 - Pencil 404
- Celery 374
 - Sea 375
 - Slender 377
- Centella**
 - asiatica* 376
 - cordifolia* 377
- Cephalalaria**
 - cephalobotrys* 402
- Chaff Flower 354
- Cheilanthes**
 - austrotenuifolia* 328
 - distans* 329
 - sieberi* subsp. *sieberi* 330
 - tenuifolia* 328
- Cherry
 - Sour 367
 - Wild Black 369
- Christella**
 - dentata* 333
 - hispidula* 333
- Ciclospermum**
 - leptophyllum* * 377
- Clubmoss
 - Bushy 311
 - Scrambling 310
 - Slender 311
- Comb Fern
 - Branched 335
 - Forked 335
- Common Horsetail 299
- Conium**
 - maculatum* * 378
- Cotton Bush
 - Balloon 408
 - Narrow-leaved 407
- Calcitra**
 - dubia* 293
- CUPRESSACEAE 339–340
- CYATHEACEAE 285–286

- Cyathea** 286
 australis 285
 cooperi * 285
 leichhardtiana 286

- Cyclosorus**
 interruptus 334

- Cynanchum**
 elegans 406

- Cyrtomium**
 falcatum * 295

D

- Daucus**
 carota * 378
 glochidiatus 379

- Davallia**
 pyxidata 287

DAVALLIACEAE 286–288

- Deeringia**
 amaranthoides 363

- Dennstaedtia**
 davallioides 289

DENNSTAEDTIACEAE 289–293

- Dicksonia**
 antarctica 294

DICKSONIACEAE 293–294

- Dicranopteris**
 linearis 300

- Dictymia**
 brownii 317

- Didiscus**
 scapiger 391

- Diplazium**
 australe 274

- Doodia**
 aspera 283
 caudata
 var. *caudata* 283
 var. *laminosa* 284
 media subsp. *media* 284

DRYOPTERIDACEAE 294–298

E

- Elder**
 Ground 373

- Elkhorn** 318
English Ivy 403
 EQUISETACEAE 299

- Equisetum**
 arvense * 299

- Eryngium**
 decaisneanum * 380
 maritimum * 379
 ovinum 380
 pandanifolium * 380

- rostratum* 380
 vesiculosum 381
Euroschinus
 falcata var. *falcata* 369

F

- Felt Fern**
 Horsehoe 319
 Rock 319

- Fennel** 381

- Fig**
 Hottentot 347

- Filmy Fern**
 Bordered 306
 Common 305
 Narrow 307
 Shiny 305

- Finger Fern** 303

- Fishbone Fern** 281

- Flannel Flower** 372
 Lesser 373

- Foeniculum**
 vulgare * 381

- Fork Fern**
 Skeleton 320

- Fragrant Fern** 318

- Froelichia**
 gracilis * 364

G

- Galenia**
 pubescens * 348
 secunda 348

- Gleichenia**
 dicarpa 300
 microphylla 301
 rupestris 301

GLEICHENIACEAE 300–303

- Gomphocarpus**
 fruticosus * 407
 physocarpus * 408

- Gomphrena**
 celosioides * 364

- Goutweed** 373

GRAMMITACEAE 303

- Grammitis**
 billardieri 303

- Gristle Fern** 278

- Ground Fern**
 Common 293

- Harsh 290

- Lacy 289

- Guillemia**
 densa * 365

H

- Hare's Foot Fern 287
 Heartleaf Ice Plant 347
Hedera
 helix * 403
 Hemlock 378
Histiopteris
 incisa 289
 Hogweed 353
 Holly 398
 Holly Fern 295
Hydrocotyle
 acutiloba 383
 algida 382
 bonariensis * 382
 geraniifolia 383
 laxiflora 383
 peduncularis 384
 tripartita 384
 verticillata 385
 vulgaris 385

HYMENOPHYLLACEAE 304–308

- Hymenophyllum**
 australe 304
 bivalve 304
 cupressiforme 305
 flabellatum 305
 marginatum 306
 pumilum 306
 rarum 307
Hypolepis
 glandulifera 290
 muelleri 290
 rugosula 291

I

- Ilex**
 aquifolium * 398

J

- Japanese Lady Fern 274
 Jasmine
 Chilean 394
 Jointed Fern 287
 Small 286
 Joyweed
 Hairy 355
 Lesser 355

K

- Kangaroo Fern 317
 King Fern 316

L

- Lacy Wedge Fern 309
Lampranthus
 multiradiatus * 349
 tegens * 349
Lastreopsis
 acuminata 295
 decomposita 296
 hispidia 296
 microsora 297
 Laurel
 Cherry 367
 Portugal 368
Leichhardtia
 leptophylla 410
Leptopteris
 fraseri 315
Lilaeopsis
 polyantha 385
Lindsaea
 dimorpha 308
 linearis 309
 microphylla 309
 trichomanoides 310
 LINDSAEACEAE 308–310
Lunathrium
 japonicum 274
 petersenii 274
 LYCOPODIACEAE 310–311
Lycopodium
 cernuum 310
 deuterodensum 311
 laterale 311

M

- Macarthuria**
 neocambrica 350
Macrozamia
 communis 336
 pauli-guilielmi
 subsp. *flexuosa* 337
 secunda 337
 spiralis 338
 Maidenhair
 Common 265
 Filmy 266
 Giant 266
 Rough 267
Mandevilla
 laxa * 394
Marsdenia
 flavescens 408
 rostrata 409
 suaveolens 409
 viridiflora 410

Marsdenia
Scented 409

Marsilea
angustifolia 312
costulifera 312
hirsuta 312
mutica 313

MARSILEACEAE 312-313

Matweed
Small 365

Melodinus
australis 395

Melodinus
Southern 395

Microsorium
diversifolium 317
pustulatum 317
scandens 318

Microstrobos
fitzgeraldii 342

Milk Vine
Common 409
Hairy 408

Mollugo
verticillata 350

Moth Plant 405

N

Necklace Fern 270

Nectarine 368

Nephrolepis
cordifolia * 288

Nerium
oleander * 395

New Zealand Spinach 352

Nyssanthus
diffusa 365
erecta 366

O

Oleander 395

OPHIOGLOSSACEAE 314

Ophioglossum
lusitanicum subsp. *coriaceum* 315

Oreomyrrhis
eriopoda 386

OSMUNDACEAE 315-316

Oxyptalum
coeruleum * 410

P

Panax
Climbing 402
Elderberry 404
Parsley Fern 314

Parsnip 386

Parsonsia
brownii 396
lanceolata 396
leichhardtii 397
sp. A 397
straminea var. *straminea* 397

Pastel Flower 345

Pastinaca
sativa subsp. *sativa* * 386

Peach 368

Pear
Native 410

Pellaea
falcata var. *falcata* 331
falcata var. *nana* 332
paradoxa 332

Pennywort 376, 382, 384

Forest 383
Shield 385
Stinking 383

Pepper Tree 370

Periwinkle 398

Pigface 348

Pigweed
Giant 352

Pilularia
novae-hollandiae 313

PINACEAE 341

Pine
Black Cypress 339
Brown 343
Cluster 341
Monterey 341
Plum 343
Port Jackson 340
Radiata 341

Pinus
pinaster * 341
radiata * 341

Platycerium
bifurcatum subsp. *bifurcatum* 318

Platysace
clelandii 387
ericoides 387
lanceolata 388
linearifolia 389
stephensonii 389

Pleurosorus
rutifolius 273
subglandulosus 273

Plum
Cherry 366

PODOCARPACEAE 342-343

Podocarpus
elatus 343
spinulosus 343

Polyphlebium
venosum 307

POLYPODIACEAE 317–319

Polyscias
elegans 403
murrayi 404
sambucifolia 404

Polystichum
australiense 297
formosum 298
proliferum 298

Prickfoot 381

Prickly Alyxia 394

Prunus
cerasifera * 366
cerasus * 367
laurocerasus * 367
lusitanica * 368
persica * 368
serotina * 369

Pseuderanthemum
variabile 345

PSILOTACEAE 320–322

Psilotum
nudum 320

PTERIDACEAE 322–324

Pteridium
esculentum 292–293

Pteris
ensiformis 322
sp. aff. comans 323
tremula 323
umbrosa 335
vittata 335

Pyrrosia
confluens 319
rupestris 319

R

Rasp Fern 283

Redshank 358

Rhus
succedanea * 370

Rhus Tree 370

Ribbonwood 369

Rice Paper Plant 405

Rumohra
adiantiformis 288

S

Salvinia
molesta * 335

SALVINIACEAE 325

Schinus
areira * 370
molle var. *areira* * 370

Schizaea
bifida 335
dichotoma 335
fistulosa 335
rupestris 327

SCHIZAEACEAE 326–327

Scouring Rush 299

Screw Fern 309

SELAGINACEAE 328

Selaginella
kraussiana * 327
uliginosa 328

Sesuvium
portulacastrum 351

Shield Fern
Bristly 296
Broad 298
Creeping 297
Mother 298
Shiny 295
Spreading 302
Trim 296

Silkpod
Black 397
Common 397
Mountain 396

Silky Fan Fern 303

Silver Basswood 403

SINOPTERIDACEAE 329–333

Sphaerocionium
lyallii 308

Spleenwort
Mother 269
Shore 271
Simple 268
Weeping 271

Sticherus
flabellatus 302
lobatus 302
tener 303

Strap Fern 281
 Sycamore Maple 346

T

Tetragonia
nigrescens * 351
tetragonoides 352

Tetrapanax
papyrifer * 405

THELYPTERIDACEAE 333–334

Thunbergia
alata * 345

Tmesipteris
billardieri 320
obliqua 320
ovata 321

- parva 321
- truncata 322
- Todea
 - barbara 316
- Toxicodendron
 - succedaneum * 370
- Trachymene
 - anisocarpa 390
 - incisa subsp. incisa 390
 - procumbens 391
 - saniculifolia 391
- Treefern
 - Prickly 286
 - Rough 285
 - Soft 294
 - Straw 285
- Trianthema
 - portulacastrum * 352
 - triquetra* 353
- Trumpet
 - Blue 344
 - Dwarf Blue 344
- Tweedia
 - coerulea * 410
- Tylophora
 - barbata 411
 - woollsii 411

U

- Umbrella Fern 302
- Umbrella Tree 404

V

- Vinca
 - major * 398
- Vittaria
 - elongata 334
- VITTARIACEAE 335

W

- Water Fern
 - Alpine 282
 - Broad 279
 - Hard 282
 - Lance 277
 - Soft 280
 - Swamp 279
- Weed
 - Alligator 356
 - Barbwire 365
 - Bishop's 374
 - Gomphrena 364
 - Khaki 357
- Wood
 - Celery 403

X

- Xanthosia 393
 - atkinsoniana 392
 - dissecta 392
 - pilosa 393
 - tridentata 393
 - vestita 393
- Xanthosia 393
 - Cut-leaved 392
 - Rock 393

Z

- Zaleya
 - galericulata subsp. australis 353
- ZAMIACEAE 336-338

The natural vegetation of north-western New South Wales: notes to accompany the 1:1 000 000 vegetation map sheet

John Pickard and E.H. Norris

Print 66518

Pickard, John¹ and Norris, E.H.² (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1994. *The natural vegetation of north-western New South Wales: notes to accompany the 1:1 000 000 vegetation map sheet*. *Cunninghamia* 3 (3): 423–464. The pre-settlement vegetation of the north-western quarter of New South Wales (latitude 29–33° S, longitude 141–147° E) is interpreted and mapped at the Australian continental scale of 1:1 000 000. The area (approximately 26.6 million ha) represents 28% of the State and is mostly within the Western Division. The map shows 41 plant communities, defined by structure and characteristic species, and 28 mosaic communities. Brief descriptions are provided in the text. Vegetation is predominantly controlled by climatic and edaphic factors. The area covers much of semi-arid and arid New South Wales. Potential problems in vegetation management and conservation options are discussed.

Dedication

We dedicate this paper and map to Professor Noel Beadle in recognition of the outstanding value of his 1948 Vegetation and pastures of western New South Wales. For almost half a century his map and book have been essential and invaluable references for anyone working in semi-arid New South Wales. His fundamental contribution to understanding the landscapes of western New South Wales has never been fully recognised. On a more personal level, some 30 years ago, the work evoked images that stimulated Pickard to become a vegetation ecologist — a decision and a career never regretted. This dedication is our acknowledgement of our respect and admiration of an Australian scientist and his work.

Introduction

Vegetation maps provide an inventory of plant communities and their locations, extent and geographical distribution in the landscape. They help in the understanding of plant community distribution on the basis of various features of the landscape, as well as acting as a reference for measuring changes and rates of change in vegetation over time. They also provide important scientific base-information for land use planning and range management.

In this study the pre-settlement, natural vegetation of north-western New South Wales has been interpreted and mapped at the Australian Continental Scale (1:1 000 000) and the vegetation communities, defined by structure and characteristic species, described. It deals with over one quarter of the area of New South Wales and complements the maps of Boyland (1984) and Neldner (1984) for Queensland, and Specht (1972) for South Australia.

Map area

The 1:1 000 000 map area covers the north-western quarter of New South Wales, bounded in the north by the Queensland–New South Wales border (latitude $29^{\circ} 00'S$), in the west by the South Australia–New South Wales border (longitude $141^{\circ} 00'E$) in the south by latitude $33^{\circ} 00'S$, and in the east by longitude $147^{\circ} 00'E$ (Fig. 1). The area lies mostly within the Western Division of New South Wales and is approximately 26.6 million hectares (ha) in extent representing 28% of the State. The area is largely within the North-western Plains and North Far-western Plains botanical subdivisions. The map covers sixteen 1:250 000 maps.

Major rivers within the map include the Darling, Paroo, Warrego and Culgoa Rivers and their associated tributaries and distributaries (Fig. 1).

Resident population distribution within the area is largely confined to major centres, in particular the city of Broken Hill with an estimated 52% of the population (Australian

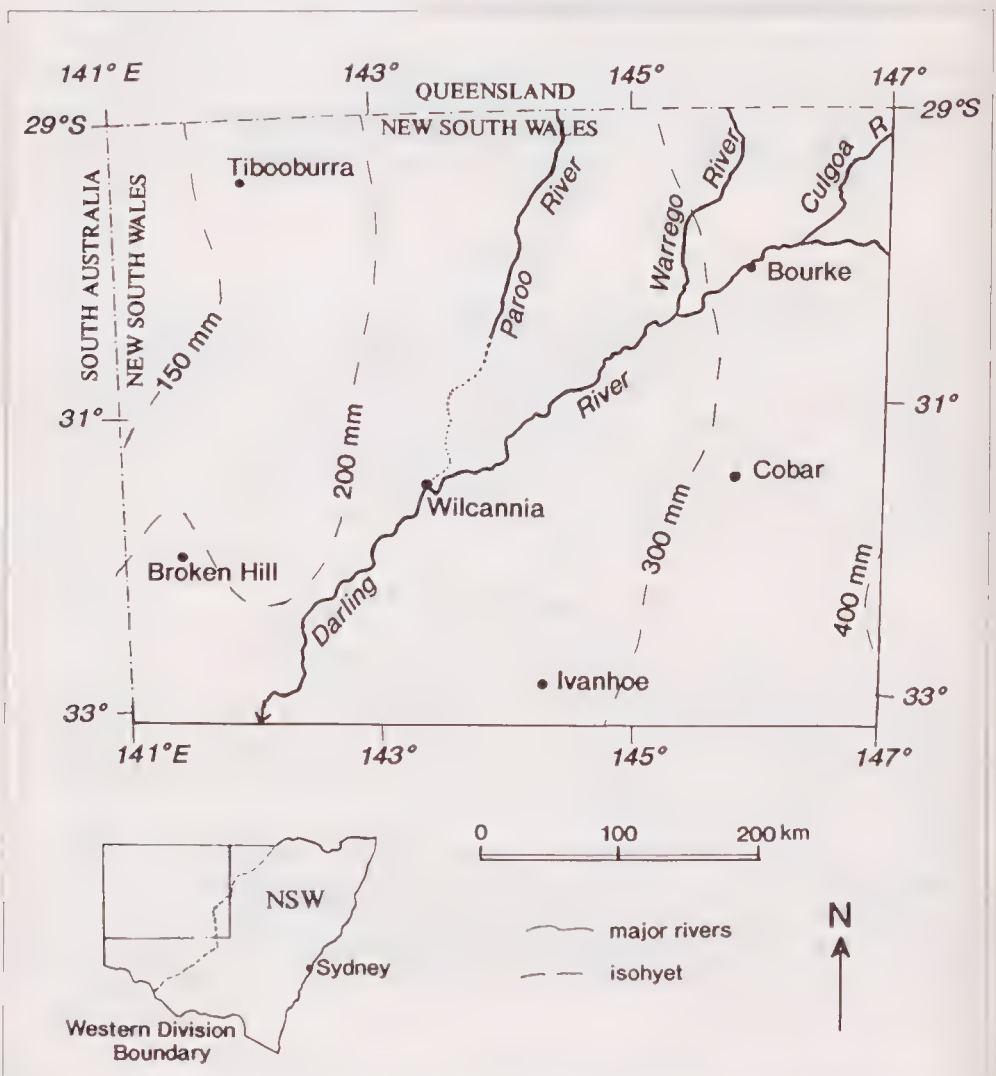


Figure 1. Map area showing main towns, rivers and rainfall isohyets.

Bureau of Statistics 1991). The Shires of Cobar and Bourke have 14% and 10% respectively. Population numbers between towns are very low and widely scattered.

Climate

The map area covers much of semi-arid and arid New South Wales. Long-term mean annual rainfall decreases from east (400 mm) to west (150 mm in the far north-west corner) (Fig. 1), with reliability decreasing from east to west (Fig. 2). Over the long term, rainfall is summer dominant for the northern areas, falling by way of convective storms, and winter dominant in the south associated with cold fronts of lower intensity (Johns, Tongway & Pickup 1984). The north-west corner experiences a fairly even spread of rainfall throughout the year. Variability is greatest in the far north-west corner, but rainfall is highly variable over the whole area and prolonged periods of low rainfall and occasional floods are characteristic.

Rainfall patterns over decades may be recognised, though records for most of the area are barely 100 years old. Despite the massive and well-publicised droughts of the late 1890s (Royal Commission 1901), the period prior to 1910 was generally wetter than from 1911 to 1947 (Gentili 1971). Since then, rainfall has been substantially higher and with a marked increase in the amount of summer rainfall (Pittock 1981). Within any one of these periods, individual years may be wetter or drier, but the decadal pattern occurs across all of the mapped area.

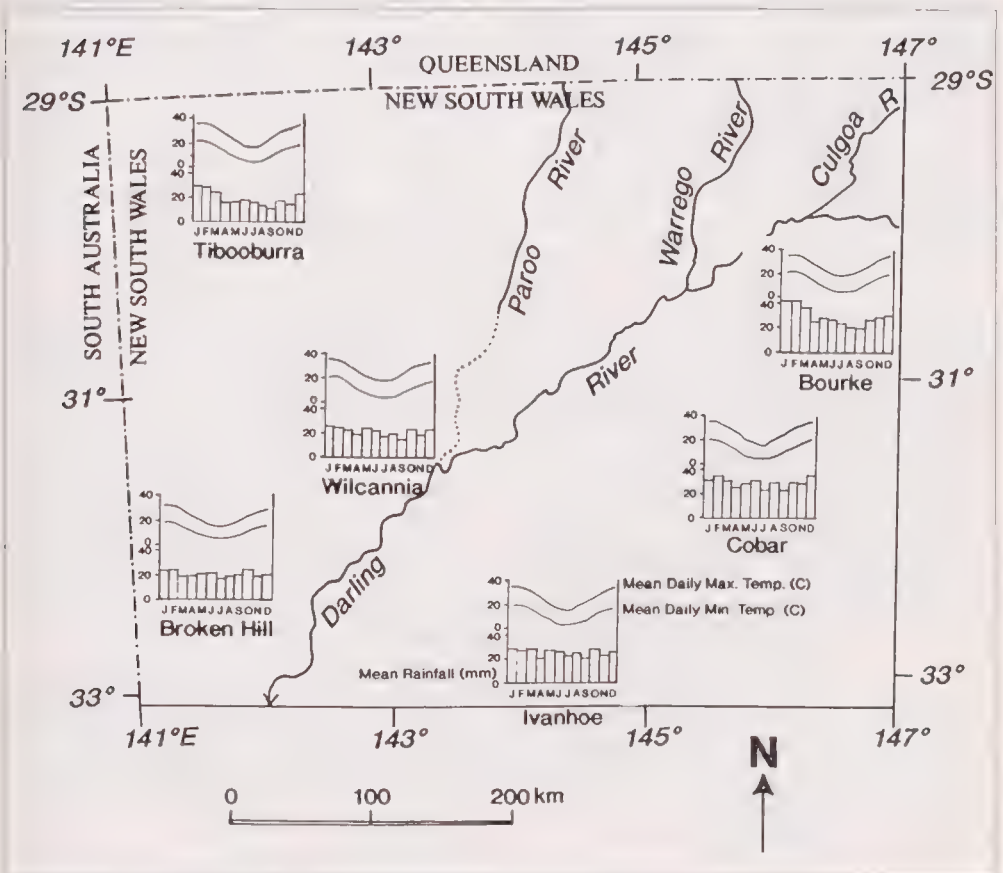


Figure 2. Monthly rainfall and temperature for major centres.

Temperatures are hot in summer and mild in winter. Figure 2 displays long-term mean monthly maximum and minimum temperatures for particular stations within the area. Major departures from maximum temperatures may occur for short periods and are not uncommon, with temperatures exceeding 40° C during December to February and exceeding 35° C during October to March (Bureau of Meteorology 1988). Available data indicate that evaporation increases from south to north and from east to west, being highest in the far north-west corner (Cunningham et al. 1981). In all months mean evaporation exceeds mean rainfall (Dalton 1988).

Frosts are common in many areas; most occur in the period May–June to August–September.

In the late 19th and early 20th centuries, massive dust storms were a common feature of western NSW (Royal Commission 1901). However, more recently, they have been less frequent. From 1957 to 1984, dust storms occurred once per two years to twice per year over most of the map area. In the southern section bordering the extensive mallee of south-western New South Wales, dust storms were more frequent in 1957 to 1984, averaging two to five per year (McTainsh et al. 1989).

Geology

The geology of the map area, summarised in Figure 3, is a complex mosaic of geological units representing rock formations of various ages overlain by more recent sediments.

The North Western Fold Belt comprises the outcrop areas of Broken Hill and the Barrier Range, the ranges in the Mootwingee area and parts of the Grey Range in the Milparinka–Tibooburra area. Most of these outcrops are Pre-Cambrian in age and consist of conglomerate, sandstone, shale, limestone, tillite, schist, gneiss, amphibolite, pegmatites and gabbro (Packham 1969; Geological Survey of NSW 1972; Cunningham et al. 1981). Small areas of Devonian sandstones, quartzites, acid lavas and chert outcrop, as well as Cretaceous sandstones, siltstones and shale. Tertiary sedimentary deposits (silcrete) are common in the Milparinka–Tibooburra area, where the oldest formations of granites, phyllites and schist can be found.

Rocks of the Central and Southern Highland Fold Belt are younger; the oldest comprise Ordovician sandstones, siltstones, chert, quartzite, limestone, tuff, andesite, slate and greywacke. Devonian and Silurian sediments and volcanics are common in the region, as well as Silurian–Devonian granites and granodiorites.

The Great Artesian Basin comprises mainly Quaternary alluvial material along the major river systems, particularly along plains in the Brewarrina district. Quaternary sands of mostly aeolian origin can be found in the western sections of the Basin. North of the Darling River are extensive areas of Cretaceous sandstones, siltstones, claystone and shale; marine shales outcropping in the White Cliffs area are the source of opal. In the deeper parts of the Basin towards the Queensland border more sandy lacustrine beds overlie sandstone and shale sequences.

In the main, the Murray Basin is a Permian–Tertiary sedimentary basin containing thick sequences of Eocene marine sediments. Reworking of the sediments since the Tertiary has resulted in a covering of Quaternary sediments of fluvial and aeolian origin (National Parks & Wildlife Service 1982). Few rock outcrops are present but include the Devonian Manara Hills north-west of Ivanhoe, and the Darnick Range south-west of Darnick.

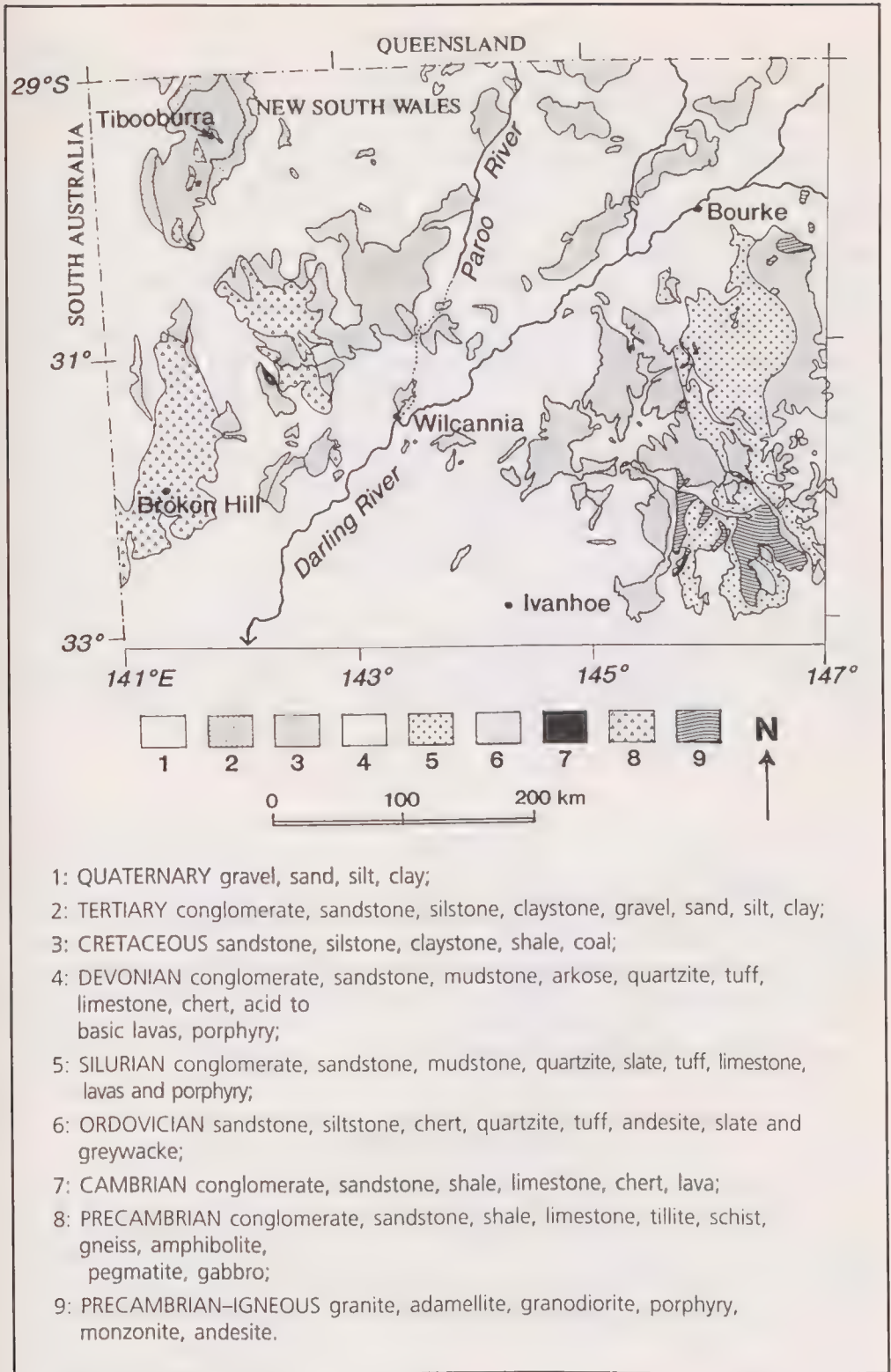


Figure 3. General geology of map area (after Packham 1969).

Geomorphology

There are two main landform types in the map area — erosional and depositional. The erosional landforms comprise only a small percentage of the area compared to the predominantly depositional environment, where wind and water have distributed and continue to distribute sediments (Cunningham et al. 1981).

Relief is dominated by the Barrier and Grey Ranges and the mesa country around White Cliffs and Mootwingee. Mt Robe (474m) in the Barrier Range is the highest point west of the Darling River. In the eastern part of the map the most extensive erosional surface is the Cobar Pediplain (Lawrie 1976), with the isolated McCullochs Range east of Wilcannia being the westerly extension of this. Approximately 80 km south of Cobar lie the Tarran Hills (508m) which represent the highest elevation in the Western Division. In other areas relief is provided by smaller ranges and isolated hills such as the Manara Hills north-west of Ivanhoe and Thoolabool Range south-west of Louth.

Much of the map area consists of level to undulating plains 70–250 m above sea level. The north-west corner is characterised by densely spaced linear sand ridges which have formed on the deepest sands. Large areas of scattered linear sand dunes can also be found south-east of Broken Hill (Australian Water Resources Council 1972). Level sand plains are common in more northerly areas (National Parks & Wildlife Service 1982).

A large proportion of the map area is drained by the Darling River through-drainage system and associated rivers. Associated with the Darling River catchment are extensive alluvial floodplains dissected by a complex network of channels and lakes which only carry water during floods. The far north-west corner of the area forms part of the extensive inland channel country where waters flow south-west and drain into Lake Frome in South Australia.

Soils

Details regarding soil types of the map area have been well documented (Stannard 1962; James 1960; Mabbutt 1973; Lawrie 1976, 1991; Cunningham et al. 1981; Soil Conservation Service various dates). Broadly, nine major soil types occur throughout the map area. Lithosols (skeletal soils), brown gibber soils and red earths are associated with areas of relief, red-brown earths and grey and brown clays are associated with alluvial plains, whilst desert loams, solonised brown soils, calcareous red earths and dune sands are associated with the aeolian plains.

History of settlement

Aboriginal occupation

Recent archaeological studies suggest that Aborigines have occupied western New South Wales for at least 40 000 years (Bowler 1971, Allen 1980). During this time the climate, flora and fauna have changed substantially and the distribution of occupation over time is in part due to the availability of food and other resources, in particular fresh water (National Parks & Wildlife Service 1982).

The Aborigines may have largely altered the ecosystems in which they lived by the use of fire to aid their hunting and gathering and through their use of local resources generally. However, unlike the Europeans, it seems likely that the Aborigines had a

kinship with the land (Pickard 1990b). From accounts by the early explorers (Mitchell 1838; Sturt 1849), Aboriginal occupation in the recent past seems to have been centred on the major river systems, and the drier country away from permanent water sources was used opportunistically when seasonal or heavy rains permitted hunting in more favoured areas. However, Aborigines overcame the lack of permanent water in the drier areas, since it has been found that occupation on a regular basis away from rivers was quite common (Harris 1989).

European Occupation

After the early exploring expeditions, initial settlement on lands east of the Darling River was slow, due to Government policy aimed at controlling land occupancy within the 19 counties of the 'Limits of Location'. However, squatters gradually spread out onto adjoining lands and the pressure for land settlement was such that in 1836 by Act of Council, it was decided to allow squatters to graze their stock, paying an annual fee of 10 pounds (King 1957). By 1850 the frontages of the Darling River up to Wilcannia had been occupied (National Parks & Wildlife Service 1982). Most of the land east of the River had also been taken up but settlement was limited by lack of permanent water; the land could only be used opportunistically after rains.

Land west of the Darling River was settled later, mainly associated with the more reliable sources of water such as the Darling River and smaller, often ephemeral, supplies along local drainage areas, for example in the Barrier Range (Mabbutt 1973). The discovery of the vast artesian water supply and the subsequent sinking of bores and construction of wells paved the way for a greater settlement in drier areas and by the end of the 19th century the majority of the map area was settled.

Land use

Arid and semi-arid rangelands of western New South Wales have now been grazed for between 110–140 years (Cunningham & Milthorpe 1981, Pickard in press a). During this time there have been various irreversible soil and vegetation changes.

The squatters brought in large numbers of domestic stock. Cattle predominated at first but were later replaced by sheep (Cunningham et al. 1981) with wool production becoming the major industry. Mining assisted in opening up many areas away from permanent water, particularly during the gold boom of the 1850s. Broken Hill and Cobar remain today as viable centres through mining for silver, lead and zinc, whilst opals are mined at Lightning Ridge and White Cliffs.

Currently, the main land use is pastoral with sheep remaining the most numerous domestic animal. Cattle numbers fluctuate in response to price and market availability. Some of the large feral goat population is periodically trapped and sold for meat and for introduction into mohair-producing flocks (Cunningham et al. 1981). Dryland cropping is undertaken during favourable times particularly along the eastern edges of the map area, and on some of the dry lakebeds such as Lake Tandou.

Less than 3% of the map area is conserved in National Parks, Nature Reserves and Historic Sites managed by the National Parks & Wildlife Service. The Forestry Commission of NSW has a Forest Preserve and some Timber Reserves in the eastern section of the map sheet.

Land tenure

Lands to the eastern edge of the map sheet and lying outside the Western Division are mostly held under freehold title. However, most of the map area lies within the Western Division and is predominantly held under leasehold tenure; the bulk of this is held under perpetual lease (Condon 1976). A large proportion of these holdings are held as Western Lands Leases through the Western Lands Act of 1901. Western Lands Leases may be for grazing and agriculture, town residential blocks and business sites (Western Lands Commission 1990). A very few other holdings remain under the Crown Lands Act.

Leasehold land allows restrictions to be placed on the term of the lease as well as some control over land use — for example, control of land use for a specific purpose such as pastoralism, control of the intensity of use (limiting stock numbers), setting conditions for the control of noxious plants and animals, encouraging land improvements, and the right of the Crown to minerals (Western Lands Commission 1990).

Review of vegetation and studies

Charles Sturt during his 1844–46 exploration of the interior of the continent first described the vegetation and collected plant material (Sturt 1849). Cabbage (1900a, 1900b) made notes on plant species and habitats in the Bourke to Cobar and Cobar to the Bogan River above Nyngan. Turner (1903, 1905) described plant species of the Darling and north-western New South Wales regions. Haviland (1911, 1913) described species and their habitats from the Cobar country, including a map with place names and localities and MacGillivray (1923) described plant species whilst travelling north through the Barrier and Grey Ranges. Collins (1923, 1924) produced the first detailed discussions on the flora and ecology of the Grey Ranges, discussing predominant vegetation types and habitats, associated species, and annual flora.

Beadle (1948) published the first vegetation map of western NSW and his 1:1 024 000 scale map (1" = 16 miles) and its accompanying memoir have remained the standard reference to the vegetation ever since. Although produced before the advent of air photos and under rather difficult conditions (Beadle 1981a), it is remarkably accurate. The detailed notes of the memoir are mandatory reading for the serious student of the vegetation of western NSW. An interesting account of Beadle's first trip to the west in 1939 is given in Beadle (1981b).

A vegetation map of the Paroo–Upper Darling region was compiled by James (1960) as part of his erosion survey of that region. Stannard (1963) carried out similar work in the central East–Darling region. Morris (1939) discussed plant regeneration at Broken Hill and west Darling region plants (Morris 1966); Milthorpe (1972) and Burrell (1973) described vegetation in the Fowlers Gap–Calindary area north of Broken Hill.

Vegetation studies in adjacent areas include those of Specht (1972) for South Australia and Dawson and Boyland (1974) and Boyland (1974) for Queensland. More recent studies include those of Cunningham et al. (1981), Cunningham & Milthorpe (1981), Beadle (1981a), Soil Conservation Service of NSW (various dates), and include Dalton 1988; Irons & Quinlan 1988; Iwaszkiewicz & Semple 1988), Boyland (1984), Neldner (1984), Fox (1991), Milthorpe (1991), Porteners (1993), Scott (1992), Walker (1991) and Wade (1992). Extensive bibliographies list research papers and publications dealing with a range of subjects relating to the Western Division (Moore 1986; Semple & Irons 1989; Parson 1990, 1991).

Methods

Mapping procedure was based primarily on the reinterpretation of existing 1:250 000 scale geological maps of the area, as a strong relationship between geological type and vegetation type became apparent from early fieldwork. Preliminary maps at 1:250 000 scale were field-checked over many seasons from 1971 to 1978 using extensive ground traverses on most public roads and many station tracks in the area (Fig. 4). This was carried out by Pickard during his employment as plant ecologist with the Royal Botanic Gardens. At this stage, the maps included many vegetation units smaller than 2 km across. These individual maps were photo-reduced to 1:1 000 000 scale and the vegetation was compiled onto a single base map. During this transfer, very small units were omitted, and the boundaries simplified somewhat. Some boundaries needed modification where they crossed borders of the compilation sheets, but this was usually minor. Further field checking followed. Specific areas were also checked using existing Land System maps published by the Soil Conservation Service of NSW, Landsat satellite images, and occasionally, air photos.

Such a procedure is appropriate in large semi-arid and arid areas such as this where maps are to be published at 1: 1 000 000 scale. Beard pioneered this rapid technique in his vegetation maps of Western Australia (e.g. Beard 1974, Beard & Webb 1974). The basis of the technique is that geological maps are prepared by interpreting air

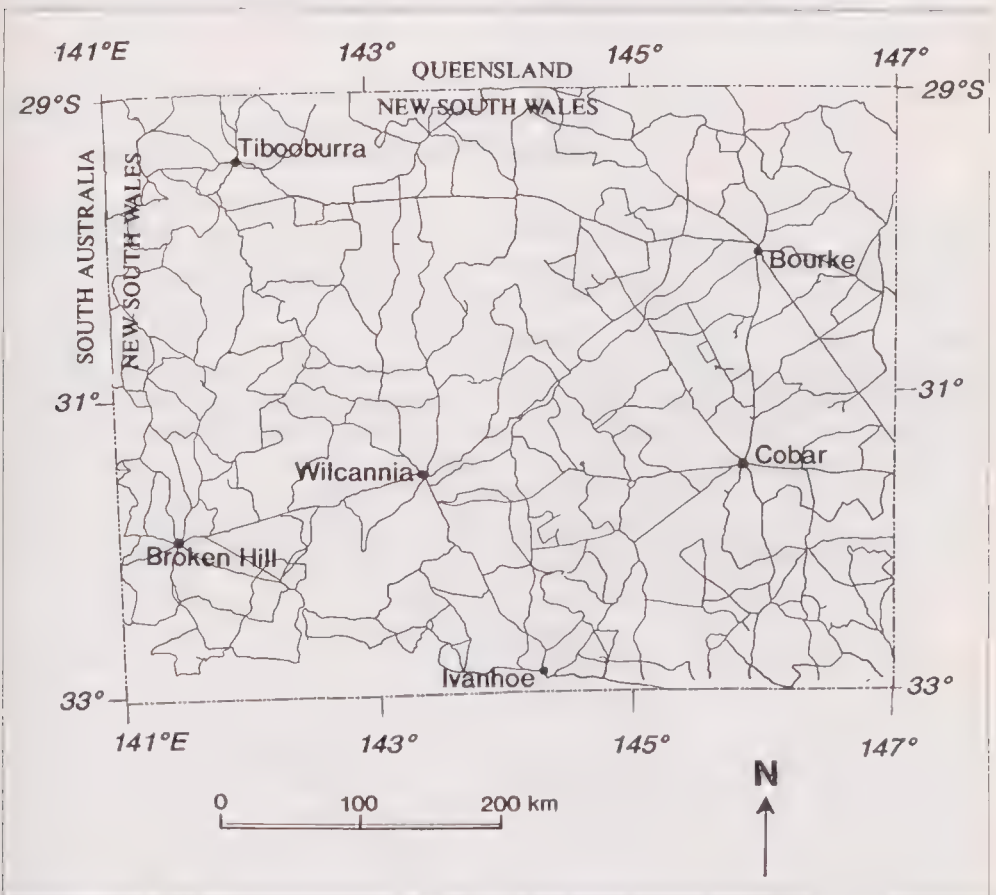


Figure 4. Extent of vehicular traverses of map area during field work.

photo patterns which include vegetation. Despite Beadle's (1948) earlier conclusion, it is clear that one of the primary controls of vegetation in western NSW is geology.

The accuracy of the technique has been compared with that of vegetation maps produced by direct air photo interpretation. Pickard & Boyland (1981) compared a draft of the present map and an adjoining 1:500 000 scale vegetation map in Queensland. The Queensland map was prepared by interpreting stereo pairs of 1:80 000 scale air photos, compiling land systems at 1:250 000 before final vegetation mapping at 1:500 000. There were very few boundaries displaced on the border by more than 5 km, and most of these could be reconciled by slightly expanding the definitions of the vegetation units.

Such adjustments recognise the subjectivity inherent in vegetation mapping (Pickard 1983). Within a single map sheet, the units should be consistently conceived, described and mapped. However, there will be greater or lesser inconsistencies between mappers. This does not present major problems because, as Pickard & Boyland (1981) showed, differences are readily reconciled for continent-wide standardisation.

Draft copies of the map have been widely available over the last decade. However, there has been little feedback on the accuracy of the map. While this may suggest that the users were all satisfied with the map, a more likely explanation is inertia, and the perceived difficulty in writing to report a problem. Publication of the map has been in response to the continuing need for information on the vegetation of western New South Wales and the Western Division. The draft map, prepared by Pickard, has been redrawn and some corrections made by Norris in consultation with Pickard.

Using the map

Cartographic printing limits the smallest area that can be depicted on a map to about 3 mm across. This represents 3 km at the 1: 1 000 000 scale. In other words, the map is unable to resolve or display different communities or variation finer than 3 km. This has important consequences for both preparing and using the map.

Since the smallest unit shown on this map is about 3 mm across, representing 3 km on the ground, any vegetation community, no matter how distinct, that is smaller than this will not be shown. Thus a small rocky hill may support a very distinctive and easily recognised community of *Eucalyptus vicina*. However, because the hill is only 1.5 km across, it is simply not mapped as different from the surrounding *Eucalyptus populnea* subsp. *bimbil* woodland. This does not mean that the map is inaccurate — it simply reflects the limitations of scale inherent in cartography. Therefore, attempts to digitise the map and subsequently enlarge portions to, say 1:250 000 will not improve the accuracy.

Vegetation overview

Although the vegetation cover shown on the map is presented as the pre-settlement distribution, it is largely based on present-day conditions, with extrapolation into areas that have been completely or partially changed. This is to meet the map's purpose as a baseline description for the whole area. The descriptions, however, reflect present-day conditions and concentrate on major perennial species. Regrettably there are little data on the ephemeral component of the vegetation or of the changes that have been incurred because of stock and rabbit grazing. Norris prepared the descrip-

tions of the map units using a range of references, including Pickard's field notes and in consultation with him. References to other sources of information on the vegetation are given where possible. Botanical names follow Harden (1990–1993), though it has not always been possible to determine all subspecies. For example, subspecies of *Alectryon oleifolius* and *Senna artemesioides* are only given where certainly known.

General description

Much of the western area of the map sheet supports small trees of Mulga, *Acacia aneura*, with dense stands occurring between the Darling River and the Cobar–Byrock district. Elsewhere, Mulga forms open-woodlands with its density decreasing westward as aridity increases. To the east and south-east it merges with Bimble Box (also known as Poplar Box), *Eucalyptus populnea* and other woodlands, while to the south with shrublands predominantly of *Atriplex*, *Maireana*, *Casuarina pauper* and Mallee (*Eucalyptus socialis*, *Eucalyptus dumosa*).

Climatic and edaphic factors are the major controls on vegetation growth in the region and these have been discussed elsewhere (Beadle 1948; Cunningham et al. 1981; Eldridge 1988; Milthorpe 1991). Other factors such as topography, fire, flood, drought and management are also important for plant growth and survival.

Plant communities

There are 41 plant communities recognised and mapped (Table 1) and a further 28 mosaic communities also recognised.

Map unit 1

Callitris glaucophylla open-forest

(White Cypress Pine)

Geographic distribution: Generally extends from Queensland to Victoria on sandy areas throughout western New South Wales and also occurs in South Australia, Western Australia and the Northern Territory. In New South Wales communities are widespread, and mapped west of the Noonthorrange Range, north of Mootwingee and north-west and south-west of Cobar. Two other smaller areas are mapped east of Milparinka and east of Menindee.

Landforms: Gently undulating to rolling topography, but not in depressions.

Soils: Predominantly sandy, often infertile with a pH ranging from 5–7.4. On shallow stony soils in the eastern area of its range it is replaced by Black Cypress Pine, *Callitris endlicheri*.

Structure: Where it forms dense stands, *Callitris glaucophylla* suppresses herbaceous ground cover, its own litter forming a thin layer so that the ground is almost free of small plants. It is very fire-sensitive and is susceptible to grazing by stock and rabbits.

Map unit 2

Callitris glaucophylla – *Eucalyptus intertexta* open-forest

(White Cypress Pine–Red Box)

Geographic distribution: Widespread in the south-eastern corner of the map sheet, and also for a small area east of Byrock.

Landforms: Level to undulating country and low gravelly rises.

Soils: Red-brown clay loams, sandy loams and gravelly soils in elevated positions.

Structure: These communities form extensive open-forests, 20–24 m in height.

Canopy species: *Grevillea striata*, *Brachychiton populneus* and *Acacia excelsa*.

Other species: The understorey is commonly shrubby and includes *Eremophila mitchellii*, *Geijera parviflora*, *Alectryon oleifolius*, *Apophyllum anomalum*, *Senna artemisioides* (various subspp.), *Dodonaea viscosa* subsp. *angustissima* and *Eremophila longifolia*.

The herbaceous layer, although sparse, is dominated by *Aristida jerichoensis* var. *subspinulifera*, *Eragrostis*

Table 1. Plant communities and map units recognised and described for the vegetation map of north-western New South Wales

Open forest	1 <i>Callitris glaucophylla</i>
	2 <i>Callitris glaucophylla</i> – <i>Eucalyptus intertexta</i>
	3 <i>Eucalyptus ochrophloia</i>
	4 <i>Eucalyptus coolabah</i> subsp. <i>coolabah</i>
Woodland	5 <i>Eucalyptus populnea</i> subsp. <i>bimbil</i>
	6 <i>Eucalyptus populnea</i> subsp. <i>bimbil</i> – <i>Callitris glaucophylla</i>
	7 <i>Eucalyptus populnea</i> subsp. <i>bimbil</i> – <i>Eucalyptus intertexta</i>
	8 <i>Eucalyptus intertexta</i> – <i>Acacia aneura</i>
	9 <i>Eucalyptus melanophloia</i> – <i>Triodia mitchellii</i> var. <i>breviloba</i>
	10 <i>Eucalyptus microcarpa</i> (narrow-leaved race)
	11 <i>Eucalyptus camaldulensis</i>
	12 <i>Acacia excelsa</i>
Open woodland	13 <i>Eucalyptus</i> aff. <i>terminalis</i> – <i>Eucalyptus populnea</i> subsp. <i>bimbil</i>
Low open forest	14 <i>Callitris glaucophylla</i>
	15 <i>Eucalyptus largiflorens</i>
	16 <i>Acacia cambagei</i>
	17 <i>Acacia harpophylla</i>
Low woodland	18 <i>Casuarina pauper</i> – <i>Alectryon oleifolius</i> subsp. <i>canescens</i>
	19 <i>Eucalyptus</i> aff. <i>terminalis</i> – <i>Atalaya hemiglaucula</i>
Tall shrubland	20 <i>Eucalyptus socialis</i> (sandplain)
	21 <i>Eucalyptus socialis</i> (rocky hills)
	22 <i>Eucalyptus vicina</i>
	23 <i>Eucalyptus gillii</i>
	24 <i>Acacia aneura</i> (sandplain)
	25 <i>Acacia aneura</i> (rocky hills)
	26 <i>Acacia aneura</i> – <i>Acacia ligulata</i>
	27 <i>Acacia aneura</i> – <i>Acacia tetragonophylla</i>
	28 <i>Acacia aneura</i> – <i>Acacia excelsa</i> – <i>Geijera parviflora</i>
	29 <i>Acacia loderi</i>
	30 <i>Acacia clivicola</i>
Shrubland	31 <i>Acacia ramulosa</i>
	32 <i>Acacia cana</i>
	33 <i>Atriplex nummularia</i>
Dwarf open scrub	34 <i>Atriplex vesicaria</i> (downs and ranges)
	35 <i>Atriplex vesicaria</i> (floodplains)
	36 <i>Maireana pyramidata</i>
	37 <i>Maireana sedifolia</i>
Herbland	38 <i>Eragrostis australasica</i> – <i>Muehlenbeckia florulenta</i>
Grassland	39 <i>Astrebla lappacea</i> (floodplains)
	40 <i>Astrebla</i> spp. (downs)
Salt lakes	41 Salt lake communities

Iacunaria, and *Stipa* spp. Other perennial and annual species may include *Digitaria brownii*, *Enteropogon acicularis*, *Sclerolaena diacantha*, *Chenopodium* spp., *Calotis cuneifolia*, and *Sida cunninghamii*.

Map unit 3

Eucalyptus ochrophloia open-forest

(Yapunya)

Geographic distribution: Restricted to the Paroo River (and adjacent lower reaches of adjacent Purnanga and Dingo Creeks) and channels of Cuttaburra Creek.

Landforms: Floodplains and associated channels, pans and sandy rises.

Soils: Brown clays, red texture-contrast soils, gravel and stony beds of streams.

Structure: Variable low open-forest to woodland, in essentially monotypic stands (Fig. 5). Variable amounts of *Muehlenbeckia florulenta* and *Eragrostis australasica* forming dense herbland along channels. Some patches of tall shrubs (for example *Acacia stenophylla*).

Canopy species: Generally only *Eucalyptus ochrophloia*, but on fringes a range of other trees: *E. coolabah* subsp. *coolabah*–*E. coolabah* subsp. *arida* (see notes in Map unit 4), *E. camaldulensis*, *E. populnea* subsp. *bimbil* and *E. largiflorens*.

Other species: A wide range of shrubs occupy

slightly lower (wetter) and higher (drier) sites in a bewildering manner: *Maireana aphylla*, *Acacia victoriae*, *A. stenophylla*, *Eremophila bignoniiflora*, *E. polyclada*, *E. maculata*. Herbs include *Muehlenbeckia florulenta*, *Sclerolaena muricata*, and many other annual *Sclerolaena* species and annual *Atriplex* species as well as a number of ephemeral species occurring after floods. Many grass species: *Eragrostis australasica*, *E. setifolia*, *Astrebula lappacea*, *Paspalidium jubiflorum*, *Leptochloa digitata*, *Dichanthium sericeum* and *Digitaria ammophila*.

Merges with: Other northern floodplain communities, especially *Eragrostis australasica*–*Muehlenbeckia florulenta* herbland, *Eucalyptus populnea* low open-forest, *Maireana pyramidata* low open-shrubland, as well as dryland communities.

Map unit 4

Eucalyptus coolabah subsp. *coolabah* open-forest

(Coolibah)

Geographic distribution: Floodplains of the Darling River and its tributaries upstream of Wilcannia, and especially upstream of Louth.

Landforms: Quaternary alluvium with more recent rises of sandier sediment (small source-bordering dunes), various depressions in the plains.

Soils: Grey cracking clays and grey self-mulching clays



Figure 5. *Eucalyptus ochrophloia* open-forest (Map unit 3). Cuttaburra Creek.

with gilgais and crab-holes, sandy soils on rises.

Structure: As mapped here, the community includes a wide range of structural forms, ranging from open woodland dominated by *E. coolabah* to ephemeral hermland with no single dominant. Shrub layer may be present. The extensive plains are most often essentially treeless, but are mapped here for convenience.

Canopy species: *E. coolabah*, *E. largiflorens*, *E. camaldulensis*, *Casuarina pauper*/*C. cristata*. Two subspecies are recognised in the map area: subsp. *coolabah* is common throughout on heavier soils, while subsp. *arida* is confined to the far north-western corner, usually in sandy or gravelly creek lines in stony or sandy desert country.

Other species: Shrubs: *Acacia victoriae*, *A. stenophylla*, *Atalaya hemiglaucula*, *Eremophila bignoniiflora*, *Atriplex nummularia*, *Chenopodium nitraticeum*, *Rhagodia spinescens*, dense *Dodonaea viscosa* subsp. *angustissima* on sandy rises. Herbs dominated by various annual chenopods together with a wide range of season-specific ephemerals (including grasses).

Merges with: Other southern floodplain communities (*Eucalyptus camaldulensis* open-forest, *E. largiflorens* low open-forest and *Eragrostis australasica*–*Muehlenbeckia florulenta* herbland and dryland communities (*Maireana pyramidata* (sandplain) low open-shrubland, *Atalaya hemiglaucula* open-woodland).

Map unit 5

Eucalyptus populnea subsp. *bimbil* woodland

(Bimble Box or Poplar Box)

Geographic distribution: Communities dominated by Bimble Box form extensive woodlands through parts of the map area, particularly in the eastern areas south of Bourke and around Cobar. Here they occur on plains and gentle slopes, often in seasonal drainage lines. Further west in lower rainfall areas, the community becomes more restricted to drainage lines and near White Cliffs is found essentially as a riparian community only. Some extensive stands occur in closed depressions forming "Bimble Box swamps", which are seasonally inundated. (Beetson et al. 1980.)

Landforms: Extensive slopes and low ridges, floodplains coming off stony downs, from 0.2 to 3 km wide, with incised channels, and various higher sandier patches.

Soils: Variable mixture of unconsolidated creek sediments (clay to silt to gravel), brown clays and texture-contrast soils.

Structure: The structure of Bimble Box communities varies with soil type. On moderately fertile loamy

soils and heavy clays a two-layered tree-grass structure predominates. At its maximum development communities on these sites may approach low open-forest to 10 m or more high. On lighter-textured, more sandy soils, there is frequently a variable understorey of shrubs — *Callitris glaucophylla* is often codominant.

Canopy species: Dependent on soil type: red earths support *Acacia excelsa*, *Geijera parviflora* and *Alectryon oleifolius*. Lighter soils also have *Callitris glaucophylla*, heavy clay soils in depressions have *Casuarina cristata* and *Acacia harpophylla*. *Eucalyptus microcarpa* may also be present as an associated species in alluvial and clay soils on plains and gentle slopes in the south-east of the map area.

Other species: Various shrubs including *Acacia victoriae*, *Eremophila longifolia*, *Maireana pyramidata*, *M. aphylla*, *A. tetragonophylla* and *A. aneura*. Frequently invaded by woody weeds, especially *E. sturtii* and *E. mitchellii*. Grasses and forbs are very variable, the main species being *Eragrostis setifolia*, and annual *Sclerolaena* species.

Merges with: Other floodplain communities except *Eucalyptus coolabah* open-woodland; *Maireana pyramidata* low open-shrubland (creeks); low open-woodland and low open-woodland–tall open-shrubland communities dominated by *Casuarina pauper*–*Alectryon oleifolius* and other species. Forms a boundary community between creeks entering the western side of the Paroo River. Forms mosaics with *Callitris glaucophylla* (Map unit 5/1) and *Acacia excelsa* (Map unit 5/12) adjacent to the Paroo River and Cuttaburra Creek.

Map unit 6

Eucalyptus populnea subsp. *bimbil*–*Acacia aneura*–*Acacia* spp. woodland

(Bimble Box–Mulga–*Acacia*)

Geographic distribution: These communities are widespread on the plains country south of Bourke, and are mapped for this area.

Landforms: Level to undulating plains.

Soils: Deep calcareous to acid loamy to sandy red earths.

Structure: Tree cover varies, ranging from an open structure to quite dense stands.

Canopy species: Associated species include *Acacia excelsa*, *Eucalyptus intertexta*, *E. aff. terminalis*, *Eremophila mitchellii*, *Apophyllum anomalum*.

Other species: *Senna artemisioides*, *Dodonaea viscosa* subsp. *angustissima* and *Eremophila sturtii*. Ground covers include *Aristida* spp., *Eragrostis eriopoda*, *Chloris truncata* and other perennial grasses and forbs.

Map unit 7

Eucalyptus populnea subsp. *bimbil*–*E. intertexta* woodland

(Bimble Box–Red Box)

Geographic distribution: These communities form extensive woodlands south-east of Bourke and east and north-east of Cobar.

Landforms: Relatively hilly topography.

Soils: Shallow skeletal soils having a light texture.

Structure: They form predominantly a shrub woodland with understorey species including *Geijera parvifolia*, *Senna artemisioides*, *Alectryon oleifolium* and *Eremophila mitchellii*. Other minor species of less importance include *Apophyllum anomalum*, *Senna artemisioides*, *Dodonaea viscosa* subsp. *angustissima* and *Eremophila longifolia*. Interspersed within these communities is *Eucalyptus viridis* which occurs on more shallow soils and slight rises.

As rain decreases *E. intertexta* becomes more dominant over *E. populnea* subsp. *bimbil*, especially on stony ridges and hills.

These communities sometimes grow in a mosaic with *Callitris glaucophylla* (Map unit 7/1).

Map unit 8

Eucalyptus intertexta–*Acacia aneura* woodland

(Red Box–Mulga)

Geographic distribution: These communities are mapped for a region on the western fringe of the Cobar pediplain north-west of Cobar.

Landforms: Low gravelly rises and ridge crests with sandstone or quartzite rock outcrops. They can also be found in rocky drainage lines.

Soils: Red earths, which may sometimes be quite shallow, and in the more hilly areas soils are skeletal.

Structure: *Acacia aneura* predominate in the intermediate areas between the scattered stands of *Eucalyptus intertexta*, standing 10–15 m in height.

Canopy species: Associated species include *Acacia excelsa*, *Atalaya hemiglaucula*, *Geijera parviflora*, *Grevillea striata*, *Alectryon oleifolius* and *Brachychiton populneus*. *Callitris glaucophylla* is almost entirely absent.

Other species: Shrubs may include *Pittosporum phylliraeoides*, *Senna* spp., *Eremophila* spp. (including *E. mitchellii*). The herbaceous layer may include *Aristida jerichoensis* var. *subspinulifera*, *Aristida contorta*, *Eragrostis eriopoda*, *Tripogon liliiformis*, *Monachather paradoxa*, *Thyridolepis mitchelliana*,

Paspalidium constrictum, *Sclerolaena* spp. and *Sida* spp.

Map unit 9

Eucalyptus melanophloia–*Triodia mitchellii* var. *breviloba* woodland

(Silver-leaved Ironbark–Buck Spinifex)

Geographic distribution: These communities are mapped for two localised areas north-west of Brewarrina. *Eucalyptus melanophloia* is more common in country to the east of the map sheet area.

Landforms: Sandplains and dunefields

Soils: Variable, range from deep sandy red earths to texture-contrast soils with a light clay B-horizon.

Structure: *Eucalyptus melanophloia* grows to a height of 7–10 m and commonly forms savannah woodlands with *Triodia mitchellii* var. *breviloba* (Fig. 6).

Canopy and other species: Associated species occurring within these communities are not common but may include *Acacia murrayana*, *Grevillea albilora*, *G. juncifolia*, *Micromyrtus ciliata*, and *Keraudrenia integrifolia*. Grasses and forbs may include *Eragrostis eriopoda* and *Calandrinia balonensis*.

Map unit 10

Eucalyptus microcarpa (narrow-leaved race) woodland

(Western Grey Box)

Geographic distribution: *Eucalyptus microcarpa* communities are mapped for a small area around, and east, of Bobadah representing a westerly extension of its more easterly distribution in the State.

Landforms Generally gentle slopes and plains.

Soils: Mainly red earths and red-brown earths.

Structure: Woodland, *E. microcarpa* is a medium-sized tree attaining 20 m in height.

Canopy species: *E. microcarpa* (narrow-leaved race); this species forms an extensive intermediate, with good breeding populations between *E. microcarpa* and *E. pilligaensis*. Associated species include *Callitris glaucophylla*, *Eucalyptus viridis* and *E. populnea* subsp. *bimbil*.

Other species: Shrubs include *Acacia deaneii*, *A. oswaldii*, *Hakea leucoptera*, *Pittosporum phylliraeoides* and *Eremophila longifolia*. Perennial pasture species may include *Danthonia caespitosa*, *Aristida jerichoensis* var. *subspinulifera*, *Paspalidium constrictum* and other annuals and perennial forbs.



Figure 6. *Eucalyptus melanophloia*-*Triodia mitchellii* woodland (Map unit 9).

Map unit 11

Eucalyptus camaldulensis woodland

(River Red Gum)

Geographic distribution: Along all perennial rivers and large creeks flowing in the map area. Also along major creek channels with intermittent flow.

Landforms: Meandering incised river channels and nearby levee banks; incised channels in ephemeral streams, rocky creek beds.

Soils: Generally grey cracking clays, but also any other soils in creek bottoms.

Structure: At its maximum development along the banks of the major rivers (Darling and Lachlan) this community forms a forest of trees up to 30 m high. More typically, it is an open-forest, and frequently low woodland. There is usually only one tree layer, and occasionally a tall shrub layer of, for example, *Acacia stenophylla* with much shorter *Chenopodium nitriaceum* or *Rhagodia spinescens*. *Muehlenbeckia florulenta* commonly occurs as dense to open thickets where there are large gaps in the tree canopy.

Where the community occurs in channels on broad creeks, it is usually restricted to the active and not long inactive channels. Whenever a new channel is formed, it is quickly colonised by a single or double row of *E. camaldulensis*. Whether these ever survive to form open-forest is a function of the stability of the landforms. In Wannara Creek near White Cliffs, channels have migrated > 100 m

in the past 100 years (Pickard 1994) and all the *E. camaldulensis* in traces of the oldest channels are long dead. Short-lived channels frequently show lines of dying *E. camaldulensis*, e.g. channels of Wannara Creek below "Arrowbar" homestead.

Canopy species: *Eucalyptus camaldulensis*, with variable amounts of *E. populnea* subsp. *bimbil* and *E. coolabah* depending on the site. (*E. camaldulensis* in the Barrier Range to Tibooburra area is a distinct taxon, L.A.S. Johnson pers. comm.)

Other species: *Acacia stenophylla*, *Chenopodium nitriaceum*, *Rhagodia spinescens*, *Muehlenbeckia florulenta* and a wide range of ephemerals after floods.

Merges with: All other flood plain communities. This community sometimes grows in a mosaic with *Eucalyptus populnea* subsp. *bimbil* (Map unit 5) east of White Cliffs, and *E. largiflorens* (Map unit 15) along the Darling River.

Map unit 12

Acacia excelsa woodland

(Ironwood)

Geographic distribution: *Acacia excelsa* communities are scattered and are mapped for the north-eastern portion around Louth, north of Louth, and north-west to north-east of Bourke.

Landforms: Level to undulating country on well-watered drainage flats, and may also be found on

sandplains and sand ridges.

Soils: Variable. In the Bourke district these communities grow on deep sands and are commonly associated with *Callitris glaucophylla*. On solonised brown soils and red earths *A. excelsa* grows with *A. homalophylla*, *A. aneura*, *Eremophila mitchellii*, *Grevillea striata*, *Hakea tephrosperma* and *H. leucoptera*.

Structure/Canopy species: *A. excelsa* can occur in almost pure stands, 10 m high or more, or it may intergrade with other species such as *E. populnea* – *Callitris glaucophylla*, *A. aneura* and *E. intertexta*.

Other species: May include *Pittosporum phylliraeoides*, *Apophyllum anomalum*, *Senna artemisioides*, *Dodonaea viscosa* subsp. *angustissima*, *Olearia pimelioides*. Groundcovers may include *Eragrostis eriopoda*, *Aristida jerichoensis* var. *subspinulifera*, *Dichanthium sericeum*, *Aristida contorta* and *Sclerolaena diacantha*. *Acacia excelsa* is an important drought-fodder species.

Acacia excelsa grows in a mosaic jointly with *Eucalyptus populnea* subsp. *bimbil* (Map unit 5) and *Callitris glaucophylla* (Map unit 1), ie. 12/5/1, having a limited distribution north of Bourke and north and north-east of Enngonia; with *Casuarina cristata*–*Alectryon oleifolius* (Map unit 18) in the Enngonia district; and with *Acacia aneura* (Map unit 24) north-east of Wanaaring and adjacent to the Paroo River and Cuttaburra Creek.

Map unit 13

Eucalyptus aff. *terminalis*–*E. populnea* subsp. *bimbil* open woodland

(Inland Bloodwood–Bimble Box)

Geographic distribution: This uncommon community is mapped for an area north-west of Wanaaring and west of the Paroo River towards the New South Wales–Queensland border in country largely dominated by *Acacia aneura* tall shrubland (Map unit 24).

Landforms: The landscape is characterised by extensive, slightly undulating sandplains.

Soils: Typically light-textured soils such as deep sandy to sandy loam red earths.

Canopy species: Associated species may include *Grevillea striata* and *Hakea ivoryi*.

Other species: Shrub species include *Senna artemisioides* and *Dodonaea* spp. The herbaceous layer may include *Aristida* spp., *Enneapogon avenaceus* and *Thyridolepis mitchelliana*.

Map unit 14

Callitris glaucophylla low open-forest

Geographic distribution: Scattered distribution over the south-eastern corner of the map sheet and adjacent to communities dominated by *Eucalyptus socialis* (Map unit 20), *E. vicina* (Map unit 22) and *Callitris glaucophylla*–*E. intertexta* (Map unit 2).

Landforms: Rocky hills and ranges. Here, *Callitris glaucophylla* grows well up the slopes.

Soils: Sandy to loamy lithosols which become deeper and better developed downslope.

Canopy species: *Callitris glaucophylla* (Fig. 7); associated species may include *Acacia doratoxylon*, *Eucalyptus intertexta*, *E. populnea* subsp. *bimbil*, *Myoporum mitchellii* and *Brachychiton populneus*.

Other species: Shrub species may include *Acacia decora*, *Senna artemisioides*, and scattered *Pandorea pandorana*. The herbaceous layer may be dominated by *Stipa* spp., *Aristida* spp., *Amphipogon caricinus* and other grasses and forbs.

Map unit 15

Eucalyptus largiflorens low open-forest (Black Box)

Geographic distribution: Widespread as a fringing community along creeks, around lakes and in depressions of various sizes from Tibooburra to White Cliffs and along the Darling River floodplain downstream of Wilcannia. Immediately upstream of Wilcannia both *Eucalyptus largiflorens* and *E. coolabah* subsp. *coolabah* may occur but on different sites. Further upstream, *E. coolabah* open-forest (Map unit 4) predominates.

Landforms: Intermittently flowing billabongs and anabranches adjacent to Darling River; floodplains generally, seasonally flooded internal drainage basins.

Soils: Variable; grey cracking clays with and without extensive areas of crabholes, some texture-contrast soils.

Structure: Extremely variable. At its maximum development an open-forest but more generally low open-forest and even open-woodland. Trees are typically bent, and often occur as a single line around the contour of a previous high flood line. Various shrubs (especially *Chenopodium nitraticeum* and *Acacia stenophylla*) and herbs occur forming discontinuous lower layers.

Forms complex mixtures with *Eragrostis australasica*–*Muehlenbeckia florulenta* herbland on floodplains of Paroo River, and with *Eucalyptus coolabah* on the floodplains of the Darling River.

Canopy species: *E. largiflorens*, *E. populnea* subsp. *bimbil*, *E. coolabah*, *Casuarina pauper*, *Grevillea striata*.



Figure 7. *Callitris glaucophylla* low open-forest (Map unit 14). Approximately 40 km north-west of Condobolin (32° 47' S 146° 59' E).

Other species: Dense to open stands of *Muehlenbeckia florulenta*, *Acacia stenophylla*, *Chenopodium nitrariaceum*, various *Sclerolaena* species and a range of grasses (e.g. *Eragrostis setifolia*, *Sporobolus mitchellii* and *Eragrostis australasica*). Slightly higher areas on sandier soils with annual *Sclerolaena* and *Atriplex* species, and *Enneapogon avenaceus* under *Myoporum montanum* and *Dodonaea viscosa* subsp. *angustissima*. Some *Acacia victoriae*.

Merges with: All other floodplain communities; and with communities of sandplains. Sometimes forms a mosaic with *Acacia aneura* tall shrubland (Map unit 24), *Atriplex vesicaria* shrubland (Map unit 35), and *Eragrostis australasica*–*Muehlenbeckia florulenta* (Map unit 38) where there is a mix of suitable soils and landforms.

Map unit 16

Acacia cambagei low open-forest

(Gidgee)

Geographic distribution: Large areas between the Paroo and Culgoa Rivers, north of Louth and Bourke, and replaces Brigalow, *Acacia harpophylla* as rainfall decreases to below 550 mm per year.

Landforms: Areas subjected to irregular flooding, such as along the edges of watercourses and drainage channels.

Soils: Variable, include brown and reddish-brown

clays and duplex soils on the floodplains, and desert loams along creeks.

Structure: *Acacia cambagei* characteristically forms pure stands to 10 m in height with dense interlacing canopies, or can occur in more open formations.

Canopy species: *Acacia harpophylla*, *Casuarina pauper*, *Apophyllum anomalum*, *Eremophila mitchellii*, *Flindersia maculosa*, *Acacia aneura*, *Atalaya hemiglaucula*, *Grevillea striata* and *Alectryon oleifolius*.

Other species: Shrub species may include *Atriplex nummularia*, *Rhagodia spinescens*, *Enchylaena tomentosa* and *Maireana pyramidata*. Herbaceous species may include *Paspalidium jubiflorum*, *Enteropogon acicularis*, *Digitaria* spp., *Eulalia aurea*, *Leptochloa digitata* and *Dichanthium sericeum*. Annual *Atriplex* spp. and *Sclerolaena* spp. may also be present.

The flowers and damp leaves of *Acacia cambagei* give off an offensive more-or-less faecal odour.

Merges with: Floodplain communities, and *Acacia excelsa*, *A. aneura* and *A. harpophylla* communities.

Acacia cambagei sometimes grows in a mosaic with *Eucalyptus populnea* subsp. *bimbi*–*Callitris glaucophylla* (Map units 5 and 1), *Eucalyptus camaldulensis* (Map unit 11), and *Casuarina pauper*–*Alectryon oleifolius* subsp. *canescens* (Map unit 18).



Figure 8. Low open-forest of Brigalow, *Acacia harpophylla* (Map unit 17) (29° 08' S 146° 33' E).

Map unit 17

Acacia harpophylla low open-forest (Brigalow)

Geographic distribution: Scattered occurrences of *Acacia harpophylla* communities are mapped for three localities north-east of Bourke.

Landforms: The landscape is of low-relief sandplains and sandhills. Rarely found on hills and ridges.

Soils: Soils are predominantly red clays, often with gilgai development, alluvial clays subject to flooding, and red earths with sandy clay loam topsoils.

Structure: *Acacia harpophylla* suckers easily from roots and often forms dense monospecific stands to 10–15 m in height (Fig. 8). For detailed descriptions of the structure and floristics see Isbell (1962), Pulsford (1984), Bailey (1984), Johnson (1984) and Wade (1992).

Canopy species: *Acacia harpophylla* can grow in association with *A. cambagei* and *Casuarina cristata*, and occasionally with *Callitris glaucophylla* and *A. pendula*.

Other species: The understorey usually comprises few, if any, shrubs, but may include *Dodonaea viscosa* subsp. *angustissima* and *Eremophila longifolia*. The sparse groundcover may comprise *Atriplex* spp., *Sclerolaena* spp., *Stipa* spp. and *Eragrostis eriopoda* and other grasses and forbs.

Merges with: *Acacia cambagei* and *A. excelsa* communities.

Map unit 18

Casuarina pauper–*Alectryon oleifolius* subsp. *canescens* low woodland (Belah–Rosewood)

Geographic distribution: Extensive communities over a wide area of the centre of the map from Broken Hill to west of Bourke, especially south of the Darling River towards Ivanhoe. (Some intergradation of *Casuarina pauper* with *C. cristata* occurs in the area from Bourke to west of Condobolin. *C. pauper* occurs through far western New South Wales, whilst *C. cristata* occurs further east).

Landforms: Generally on undulating sandplains with low relief.

Soils: Calcareous red earths and red earths.

Structure: Varies from parkland with clumps of open-woodland separated by very open areas, to dense scrubs and woodlands, and open forests with trees only 4–5 m apart. Consequently density of trees is highly site specific (Fig 9).

Canopy species: *Casuarina pauper*, *Alectryon oleifolius*, *Flindersia maculosa*, *Acacia aneura*. Pure stands of both dominants are common. Reynolds (1985) recognises two subspecies of *Alectryon oleifolius* in the map area. Subspecies *canescens* usually grows on sand dunes, sandy ridges and hills in the west. Subspecies *elongatus* is more common in open forests, usually on heavy soils, in the east of the mapped area.



Figure 9. Belah–Rosewood, *Casuarina pauper*–*Alectryon oleifolius* subsp. *canescens* low woodland (Map unit 18) (32° 19' S 143° 30' E).

A major variant of this community occurs in the Wilcannia–White Cliffs area. Here *Casuarina pauper*–*Alectryon oleifolius* subsp. *canescens*–*Flindersia maculosa*–*Acacia aneura* low open-woodland–tall open-shrubland occurs on two distinct site types: loam and gibbers, and sand plain and dunes. The former is restricted to hillslopes and plateaus formed on Cretaceous sediments, and adjacent downslope areas with desert loams and skeletal lithosols, generally with gibbers at surface. The latter occurs on low relief undulating sandplains, with and without extensive areas of sand dunes and swales with calcareous red earths, red sandy earths and deep sands.

The structure of both communities is extremely variable and changes rapidly over short distances from woodland (generally in parkland mosaic of denser and more open phases) to tall open-shrubland. On the hilly gibber sites there is frequently an extensive understorey of *Maireana pyramidata* and/or *Atriplex vesicaria*. The sandy sites now often support dense stands of “woody weeds”.

Other species: Dense stands of *Eremophila sturtii* and *Dodonaea viscosa* subsp. *angustissima* (both “woody weeds”), *Apophyllum anomalum*, and some invasion by *Senna artemisioides*, *Acacia cana*, *Maireana pyramidata*, *Atriplex vesicaria*, *Eremophila serrulata*, *E. longifolia*, *Rhagodia spinescens*, *Acacia tetragonophylla*. Grasses include extensive areas

of *Astrelba lappacea* on clayey sites, but on sandier sites *Eragrostis setifolia*, *Stipa nitida* and *Enneapogon avenaceus* are more common. *Eragrostis setifolia* is particularly abundant in run-on areas. *Stipa nitida* is particularly obvious after winter rainfall. Herbs are variable and are generally dominated by *Sclerolaena* spp., and various ephemerals.

Merges with: All other communities of gibber slopes and Cretaceous hills, and sandplains; especially *Acacia aneura* tall shrubland, *Maireana pyramidata* shrubland, *Atriplex vesicaria* shrubland, *Eucalyptus socialis* tall shrubland.

This community sometimes grows in a mosaic with *Acacia excelsa* (Map unit 12), *A. aneura* (Map unit 24), and with *Atriplex vesicaria* (Map unit 34).

Map unit 19

***Eucalyptus* aff. *terminalis*–*Atalaya hemiglaucula* low woodland**

(Inland Bloodwood–Whitewood)

This community is mapped for a small area south of Tibooburra. Reaching 6 m in height, the community is commonly found on crests, low rises and stony ridges. The soils comprise gravelly red loams to sandy soils. *Eucalyptus* aff. *terminalis* is to be named *Corymbia tumescens* (L.A.S. Johnson, pers. comm.).

Map unit 20

Eucalyptus socialis tall shrubland

(Red Mallee on sandplain)

Geographic distribution: Extensive areas in south of map area, east of Roto, but extending north to Cobar and west to Wilcannia. Isolated stands are known from north of Bourke and Wilcannia.

Landforms: Gently undulating sandplain.

Soils: Calcareous red earths, with abundant calcareous nodules close to surface.

Structure: Typically a shrubland of mallee individuals from 1.5–5 m tall depending on time since the last wildfire (Fig. 10). Plants have multiple stems arising from an underground lignotuber. Some stands are commonly described as “bull mallee”: very large individuals with only a few stems, but each of these up to 10 m high, forming woodland. This is typical of mallee stands which have not been burnt for many years. Wildfire kills the above-ground stems, but new stems sprout from the lignotuber. Smaller shrubs vary locally from few to very abundant. For detailed descriptions of the structure and floristics of mallee vegetation see Hill (1989), Noble (1982, 1984), and Noble *et al.* (1990).

Canopy species: *Eucalyptus socialis*, *E. dumosa*.

Other species: A very wide range of small shrubs, and herbs. The most abundant are *Melaleuca*

uncinata, *Olearia* spp., *Alectryon oleifolius* and various grasses, especially *Triodia scariosa*.

Merges with: *Casuarina pauper*–*Alectryon oleifolius* low open-woodland, *Maireana pyramidata* low open-shrubland.

This community sometimes grows in a mosaic with *Casuarina pauper*–*Alectryon oleifolius* subsp. *canescens* (Map unit 18).

Map unit 21

Eucalyptus socialis tall shrubland

(Red Mallee on rocky hills)

Geographic distribution: Scattered occurrences south and south-east of Cobar.

Landforms: These communities of *Eucalyptus socialis* occur on stony rises, low ridges and rocky hills.

Soils: Usually shallow loamy to gravelly soils.

Structure: Typical mallee shrubland 1.5–5 m tall.

Canopy species: *Eucalyptus socialis*; Associated species may include *E. populnea* subsp. *bimbil*, *E. intertexta*, *E. viridis*; and *Casuarina pauper*–*Alectryon oleifolius* and *Acacia aneura* communities.

Other species: The generally sparse understorey includes *Enchylaena tomentosa*, *Sclerolaena* spp., *Atriplex* spp., and other annual and perennial forbs and grasses.



Figure 10. *Eucalyptus socialis* tall shrubland (Map unit 20). Approximately 35 km south-east of Mt Hope (32° 57' S 146° 08' E).

Map unit 22***Eucalyptus vicina* tall shrubland**

Geographic distribution: Country around Mt Hope, the Tarran Hills, Mootwingee and the hilly areas north-west of Ivanhoe.

Landforms: Ridge tops and ridge slopes.

Soils: Skeletal well-drained soils overlying sandstone, granite, quartzite or shale.

Structure: Moderate to open tall shrubland, usually found as the dominant species occurring with *Eucalyptus sideroxylon* and *Callitris glaucophylla*. In many cases the understorey is an open to dense scrub of *Acacia doratoxylon*, although it does form open stands devoid of shrub species.

Canopy species: *Eucalyptus vicina*, *E. morrisii*, *Eucalyptus sideroxylon*, *Callitris glaucophylla*.

Other species: When shrubs are present in the understorey, species of *Prostanthera*, *Cassinia* and *Eriostemon* are common. Ground covers of *Helichrysum bracteatum* and species of *Wahlenbergia*, *Thyridolepis*, *Danthonia* and *Stipa* are usually present.

Map unit 23***Eucalyptus gillii* tall shrubland**

(Curly Mallee)

Geographic distribution: Main occurrence is in the Flinders Ranges in South Australia, but occurs in disjunct outliers in the northern sections of the Barrier Range, north of Broken Hill.

Landforms: Mainly in rocky terrain of weathered limestone or highly calcareous sandstone.

Soils: Calcareous skeletal, usually red-stained sandy soils.

Structure: Sparsely to moderately spaced trees in small clumps, 3–4 m high surrounded by *Acacia aneura* or forming continuous stands.

Canopy species: Associated species may include *Myoporum platycarpum* and *Eremophila alternifolia*.

Other species: Shrubs include *Maireana pyramidata*, *M. sedifolia* and *Atriplex vesicaria*. Ground covers include *Sclerolaena obliquicuspis* and *Zygophyllum apiculatum* beneath the canopy area, whilst the intercanopy area can be dominated by *Stipa nitida*, *S. trichophylla*, *Sclerolaena* spp. annual chenopods including *Osteocarpum acropterum*, *Atriplex angulata* and *A. lindleyi*. Annual grasses can also be found. Ground cover is rarely abundant after good rains.

Map unit 24***Acacia aneura* tall shrubland**

(Mulga on sandplain)

Geographic distribution: Extensive areas west of the Darling River and north of Wilcannia, extending to the borders (see also Sattler 1986).

Landforms: Undulating sand plain with some dunefields (especially on western side of Peery Lake and channels of Paroo River).

Soils: Calcareous red earths and deep red dune sands.

Structure: Individual stands vary from dense scrubs to open-woodlands but more typically the community forms tall shrubland of *Acacia aneura*. In the Wilcannia region there are extensive areas of dead *A. aneura*. These are currently being investigated. Many of the dead individuals have been dead for many decades. The cause of such widespread death seems to be a combination of wild-fire and perhaps stress from a drought acting on old individuals in a single cohort. In marked contrast, Mulga communities near Bourke are often extremely dense with abundant regeneration and no areas of dead individuals.

Locally on deep sand adjacent to the Peery Hills east of White Cliffs a variant community dominated by *Grevillea striata* and *Eucalyptus intertexta* occurs. This open-woodland is of variable height and density, sometimes with a dense shrub layer over a good cover of perennial grasses.

Canopy species: *Acacia aneura*, *Casuarina pauper*, *A. ligulata*, *Alectryon oleifolius* and *Flindersia maculosa*.

Other species: Shrubs: *Senna artemisioides*, *Eremophila sturtii*, *Dodonaea viscosa* subsp. *angustissima* (all three are "woody weeds"), *Myoporum montanum*, *Eremophila longifolia*, *Acacia ligulata*, *A. victoriae*, *Alectryon oleifolius*, *Maireana pyramidata*, *Rhagodia spinescens*, *Eremophila longifolia*. Grasses and forbs: *Aristida jerichoensis*, *A. contorta*, *Eragrostis eriopoda*, *Enneapogon avenaceus*, *Sclerolaena* spp. with *Themeda australis* and *Cymbopogon ambigua* in small creek lines.

Merges with: Other sandplain communities in the south: *Casuarina pauper*–*Flindersia maculosa*–*Alectryon oleifolius*–*Acacia aneura* low open-woodland–tall open shrubland. This community sometimes grows in a mosaic with *Eucalyptus populnea* subsp. *bimbil* (Map unit 5), *E. largiflorens* (Map unit 15), *Acacia cambagei* (Map unit 16), and *Eragrostis australasica*–*Muehlenbeckia florulenta* (Map unit 38).

Map unit 25***Acacia aneura* tall shrubland**

(Mulga on rocky hills)

Geographic distribution: Extensive distribution on hills and ranges over a wide area west of the Darling River around the Paroo River and Cuttaburra Creek.

Landforms: Plateaus, scarps and mesas on Cretaceous sediments.

Soils: Lithosols and desert loams, frequently with abundant gibber lag.

Structure: Moderate to open stands of *A. aneura* with extensive open areas of grassland and low open shrubland.

Canopy species: *Acacia aneura*, *Casuarina pauper*, *Flindersia maculosa*, *Atalaya hemiglauc*. On some sites the community becomes almost monotypic *A. hemiglauc* woodland.

Other species: The most common associated species are *Acacia tetragonophylla*, *Eremophila duttonii*, *E. latrobei*, *Prostanthera striatiflora*, *Ptilotus* spp., *Dodonaea viscosa* subsp. *angustissima*, *Maireana pyramidata*, *M. tomentosa*, *Pittosporum phylliraeoides*, *Senna artemisioides*, *E. sturtii*, *Apophyllum anomalum*, *Enneapogon avenaceus*, *Atriplex* spp., and *Sclerolaena* spp. Locally there are stands of *Acacia clivicola* and *A. brachystachya* on tops of scarps and mesas. Herbs include *Eragrostis parviflora* and other chenopods. Grasses are variable: *Astrelia lappacea*, *Enneapogon avenaceus*, *Aristida* spp., and *Thyridolepis mitchelliana*.

Merges with: *Astrelia lappacea* grassland on plateaus; on slopes with *Maireana pyramidata* low open-shrubland and *Casuarina pauper*–*Flindersia maculosa*–*Alectryon oleifolius*–*Acacia aneura* low open-woodland–tall open-shrubland.

Map unit 26***Acacia aneura*–*Acacia ligulata* tall shrubland**

(Mulga–Sandhill Wattle)

Geographic distribution: This community occupies a relatively large area in the far north-west of the map sheet.

Landforms: Predominates on the deep sands of the sand ridges or dune crests replacing *Acacia aneura* (Map unit 24) on the adjacent sandplain country to the east.

Soils: Usually deep neutral to alkaline sands or cemented calcareous sands.

Structure: Tree cover comprises scattered *Acacia aneura* and isolated or clumped *A. ligulata*.

Canopy species: Associated species may include *Hakea leucoptera*, *H. tephrosperma*, *Alectryon oleifolius*, *Casuarina pauper* and *Grevillea stenobotrya*.

Other species: Associated shrubs may include *Senna artemisioides*, *Dodonaea viscosa* subsp. *angustissima* and *Eremophila sturtii*. The ground storey is sparse, and variable depending on whether the soil surface is stable or unstable. Where soils are stable species may include *Enneapogon avenaceus*, *Dactyloctenium radulans*, *Aristida contorta*, *Triraphis mollis*, *Dissocarpus paradoxa*, *Sclerolaena bicornis*, *S. diacantha*, *Helipterum floribundum*, and *Ptilotus polystachyus* var. *polystachyus*. Where soils are unstable species may include *Ptilotus polystachyus* var. *polystachyus*, *Trachymene glaucifolia*, *Eriachne aristidea*, *Eragrostis dielsii* var. *dielsii*, *Salsola kali* (mostly var. *strobilifera*), *Convolvulus erubescens*, *Calotis erinacea* and *Myriocephalus stuartii*.

Merges with: This community sometimes grows in a mosaic with *Eragrostis australasica*–*Muehlenbeckia florulenta* (Map unit 38).

Map unit 27***Acacia aneura*–*Acacia tetragonophylla* tall shrubland**

(Mulga–Dead Finish)

Geographic distribution: Widespread and scattered community on rocky hills and ridges, such as the Barrier Ranges, where it is most common and extensive, the Grey Range, Scopes Range east of Broken Hill and mesas east of White Cliffs. Also occurs on both sides of the Darling River north-west of Wilcannia, and on parts of the Cobar pediplain.

Landforms: Steep to moderate slopes on hills of Devonian sandstone, rocky cliffs, abundant out-cropping sandstone.

Soils: Skeletal lithosols, some desert loams. Local patches of aeolian sediment.

Structure: Open-shrubland of rather small and stunted bushes of *Acacia aneura* and *A. tetragonophylla* with extensive open areas. Also extensive areas of dead shrubs. Cause of death may be wildfire or stress from droughts.

Canopy species: *Acacia aneura*, *Atalaya hemiglauc*, *Casuarina pauper*, *Acacia tetragonophylla*, *Grevillea striata*.

Other species: Various herbs including *Ptilotus* spp., and grasses, especially *Enneapogon avenaceus* and *Aristida contorta*.

Merges with: All communities at base of the hills, especially where sediment has accumulated on slopes of hills.

Map unit 28***Acacia aneura*–*A. excelsa*–*Geijera parviflora* tall shrubland**

(Mulga–Ironwood–Wilga)

Geographic distribution: Extensive areas of the Cobar Pediplain and surrounds.**Soils:** Sandy to loamy skeletal soils.**Canopy species:** *Acacia aneura*, *A. excelsa*, *Geijera parviflora*.**Merges with:** Interspersed with *Eucalyptus populnea* subsp. *bimbil* woodland (Map unit 5) and *Callitris glaucophylla* open-forest (Map unit 1), and forms an indistinct boundary on its eastern range with *E. populnea*–*E. intertexta* woodland (Map unit 7).**Map unit 29*****Acacia loderi* tall shrubland**

(Nelia)

Geographic distribution: Extensive stands between Broken Hill and Wilcannia, but isolated stands beyond (Fig. 11). In 240–280 mm rainfall zone.**Landforms:** Undulating sandplain with minor drainage channels, low relief.**Soils:** Calcareous red earths.**Structure:** Open-shrubland of individual shrubs to small tree, usually with several major trunks arising close to ground.**Canopy species:** *Acacia loderi*, *Casuarina pauper*, *Flindersia maculosa*. Over much of its distribution there is relatively little regeneration of *A. loderi*. This may be due to a combination of grazing by stock and death of young individuals by wildfire. Large old individuals are particularly susceptible to killing by fire. Litter of bark, twigs, branches and wind-blown plant material accumulated at the base of the plants burns during fires, killing the plants even though the canopy is barely scorched.**Other species:** *Acacia aneura*, *Maireana pyramidata*, *Eremophila sturtii*, various grasses, especially *Stipa* ssp.**Merges with:** Surrounding community of *Casuarina pauper*–*Alectryon oleifolius* open-woodland.**Map unit 30*****Acacia clivicola* tall shrubland**

(Bastard Mulga)

Geographic distribution: Cootaurundee Range west of White Cliffs, and various mesas in the Warwick Hills east of White Cliffs.**Landforms:** In the White Cliffs area it occurs on the crest of sandstone ranges and mesas and on plateaus of Cretaceous sediments, stony surface with considerable outcrop of bedrock (Fig 12). On the Queensland border it occurs on extensive sandplains.

Figure 11. *Acacia loderi* tall shrubland (Map unit 29). Approximately 120 km north of Ivanhoe (32° 08' S 144° 08' E).



Figure 12. *Acacia clivicola* tall shrubland (Map unit 30). Crest of Cootaurundee Range, 12 km east of Wertago (30° 56' S 142° 37' E).

Soils: Skeletal lithosols, and red sandy loams.

Structure: Variable shrubland of low and twisted, often multistemmed shrubs. Variable understorey of shrubs and herbs.

Canopy species: *Acacia clivicola*, *A. aneura*, *A. ramulosa*.

Other species: *Maireana pyramidata* and various grasses *Aristida* spp., *Thyridolepis mitchelliana* and *Digitaria* spp. Forbs include *Sida* spp. and *Abutilon* spp.

Merges with: All adjacent communities in these ranges, and on the sandplains.

Map unit 31

Acacia ramulosa shrubland

(Horse Mulga)

Geographic distribution: Ranges and hills west of Brewarrina, and especially west of Wilcannia.

Landforms: Rounded hills, particularly with exposed bedrock of Devonian sandstone, gentle slopes. Also on sand dunes.

Soils: Shallow lithosols, calcareous red earths.

Structure: Typical shrubland of multistemmed shrubs, very bushy and spreading individuals, occasional emergent small trees, variable understorey of low shrubs and herbs (Fig 13).

Canopy species: *Acacia ramulosa*, *A. aneura*, *A. brachystachya*, *Casuarina pauper*, *Flindersia maculosa*.

Other species: *Maireana pyramidata*, various other perennial chenopods.

Merges with: Adjacent communities, especially *Acacia aneura*–*A. tetragonophylla* open-shrubland, *Casuarina pauper*–*Alectryon oleifolius* open-woodland. *Acacia ramulosa* Shrubland is often found on small rocky hills within *Eucalyptus populnea* subsp. *bimbil*, *Eucalyptus intertexta* and *Acacia aneura* communities.

Map unit 32

Acacia cana shrubland

(Cabbage-tree Wattle)

Geographic distribution: Communities are scattered and are mapped for the north-west of the region, particularly in the White Cliffs area.

Landforms: Broad sandy watercourse areas and adjacent low rises.

Soils: Red earths or brown gibber soils on creek floodplains, and hardsetting, scalded red soils, and lighter-textured soils on rises.

Structure: Shrubland to 4 m forming dense pure stands or widely scattered trees.

Canopy species: *Acacia aneura*, *Flindersia maculosa*, *Casuarina pauper*, and *Alectryon oleifolius*. *Acacia cana* sometimes replaces *A. cambagei* along shallow watercourses.



Figure 13. *Acacia ramulosa* shrubland (Map unit 31). The Dolo Hills, approximately 80 km west of Wilcannia (31° 43' S 142° 43' E).

Other species: Shrub species within these communities include *Eremophila sturtii*, *E. maculata*, *Dodonaea viscosa* subsp. *angustissima*, and *Senna* spp. Ground covers may include *Chloris truncata*, *Eragrostis dielsii*, *E. parviflora*, *Triplaris mollis*, and *Dactyloctenium radulans*, and species of *Atriplex* and *Sclerolaena*.

Map unit 33

Atriplex nummularia shrubland

(Old Man Saltbush)

Geographic distribution: Floodplain of Darling River close to junction with Paroo River, and in southernmost sections of Paroo River; north of Clifton Bore in the Bulloo Overflow.

Landforms: Alluvial plains, periodically flooded; sandy rises adjacent to floodplains.

Soils: Grey clays and texture contrast soils.

Structure: Open-shrubland to shrubland up to 2.5 m high with variable grass and forb layer after floods. Some anecdotal evidence suggests that many of the *Atriplex nummularia* communities in the map area are the results of natural spread from deliberate plantings in suitable habitats. However, some survey plans from the 1880s near Wilcannia have the annotation 'Giant Saltbush', indicating that *A. nummularia* was present at the time (Fig. 14).

Atriplex nummularia occurs as an understorey in *Eucalyptus coolabah*, *E. largiflorens* and *Acacia*

pendula communities. Formerly it formed extensive stands in *A. pendula* but these have now been destroyed. It also forms localised stands along drainage lines and in depressions throughout *Atriplex vesicaria* shrublands.

Canopy species: *Atriplex nummularia*, *Eragrostis australasica*, *Muehlenbeckia florulenta*, *Chenopodium nitrariaceum*.

Other species: *Sclerolaena muricata*, annual *Atriplex* spp., various ephemerals.

Merges with: *Eragrostis australasica*–*Muehlenbeckia florulenta* Herbland, *Eucalyptus coolabah* open-woodland.

Map unit 34

Atriplex vesicaria dwarf open-scrub

(Bladder Saltbush on downs and ranges)

Geographic distribution: Widespread in the north-west of map area from Wilcannia to both South Australian and Queensland borders.

Landforms: Broad undulating stony plains, often on plateaus, and on stony ranges.

Soils: Brown desert loams with extensive lags of silcrete gibbers, gilgai brown clays; skeletal lithosols.

Structure: Moderate to sparse *Atriplex vesicaria* forming dwarf open-scrub with open inter-bush areas. On strongly gilgaied sites, *Astrebla lappacea* and various herbs usually occur in the depression

and *Atriplex vesicaria* on the rises. On rocky ranges, the inter-bush areas are frequently occupied by various herbs and low shrubs.

Canopy species: Vary with the site and habitat. Downs often have *Atriplex vesicaria*, *Maireana pyramidata* (especially in sandier soils in drainage lines), and *Astrebla lappacea*. Ranges and rocky sites often have *Atriplex vesicaria*, *Maireana pyramidata* with scattered emergent *Acacia aneura* and *Casuarina pauper*. Low open woodland of *Acacia cana* on sandier rises and in creeks.

Other species: Wide range of herbs and grasses, especially *Astrebla lappacea*. In some areas, scattered *Sarcostemma australe* and *Sclerostegia* spp. occur. Ground cover species on downs are usually short-lived perennial grasses, especially *Enneapogon* spp., *Triraphis mollis*, *Sporobolus actinocladius*, *Dichanthium sericeum*, and the more long-lived perennial *Eragrostis setifolia*. Common forbs include *Sclerolaena brachyptera*, *S. eriantha* and *S. ventricosa*.

Merges with: *Astrebla lappacea* grassland, communities dominated by combinations of *Acacia aneura* and *Casuarina pauper* on gibber uplands; communities dominated by *Acacia aneura* on ranges.

Map unit 35

Atriplex vesicaria dwarf open-scrub (Bladder Saltbush on floodplains)

Geographic distribution: Widespread in the north and north-east of the mapped area, for example in floodplains of the Darling and Bogan Rivers, and Cuttaburra Creek.

Landforms: Floodplains and low-lying areas.

Soils: Typically grey and brown cracking clays, and shallow-surfaced-red brown earths.

Structure: Moderate *Atriplex vesicaria* forming a dwarf open-scrub (Fig. 15).

Canopy species: *Maireana pyramidata*, *Maireana aphylla* and *Nitraria billardieri* may be present and *Atriplex nummularia* may also form localised patches. These communities are mainly treeless but may have a tree cover of *Eucalyptus coolabah* subsp. *coolabah* or *Acacia pendula*.

Other species: Between *Atriplex vesicaria* bushes are forbs and grasses of varying quantity depending on the season.

Atriplex vesicaria shrubland sometimes grows in a mosaic with *Astrebla lappacea* (Map unit 39) and after a series of years of summer-dominated rainfall, *Astrebla lappacea* can become more prominent.



Figure 14. *Atriplex nummularia* shrubland (Map unit 33). Near Wilcannia (31° 35' S 143° 23' E).



Figure 15. *Atriplex vesicaria* dwarf open-scrub (Map unit 35). Between Conoble and Trida.

Map unit 36

***Maireana pyramidata* dwarf open-scrub**

(Black Bluebush on sandy loam texture contrast soils)

Geographic distribution: Widespread in the Broken Hill–Wilcannia–White Cliffs area.

Landform: Extensive undulating sandplains with aeolian reworking and usually with a texture contrast, higher areas on floodplains of Darling River. Also on broad sandy creeks and lower stony slopes of rises.

Soils: Texture-contrast soils, red desert loams in creeks and on edges of rises.

Structure: Dense to sparse and extensive areas of *Maireana pyramidata*. Locally there may be numerous small bushes which indicate post-World War II establishment of new plants. There may be emergent small trees, and invasion by “woody weeds” forming dense thickets.

Canopy species: *Maireana pyramidata*, emergents include *Casuarina pauper*, *Atalaya hemiglauca*, *Acacia aneura* and *Flindersia maculosa*. *M. astrotricha* is commonly mixed with *M. pyramidata* and becomes more common on shallower soils. *M. aphylla* may be locally co-dominant, especially in broad drainage lines.

Other species: Shrubs: *Senna artemisioides*, *Dodonaea viscosa* subsp. *angustissima*, *Eremophila sturtii*. Locally *Acacia victoriae* may be abundant.

Locally there may be extensive invasion by *Lycium ferocissimum* and *Solanum glaucum*.

Interbush areas support a variety of forbs and grasses. Forbs: *Sclerolaena* spp., *Brachycome* spp., *Calotis* spp., *Helichrysum* spp., *Helipterum* spp. and *Medicago* spp. Grasses: *Stipa nitida*, *Enneapogon avenaceus*, *Eragrostis setifolia*, *Danthonia caespitosa*, *Aristida* spp., *Vulpia* spp., and *Bromus* spp. Annual species of *Atriplex* and *Sclerolaena* (especially *S. muricata*), *Eragrostis parviflora*.

Merges with: Other communities of sandplains (especially *Casuarina pauper*–*Alectryon oleifolius*) and *Atriplex vesicaria* on more clayey soils.

Map unit 37

***Maireana pyramidata* dwarf open-scrub**

(Blackbush on loams and gibbers)

Geographic distribution: In the Barrier Ranges north of Broken Hill, and in the Noonthorangee Range west of White Cliffs.

Landforms: Rocky rises and ridges, extensive undulating plains of gibbers, adjoining slopes and associated broad drainage lines.

Soils: Self-mulching brown clays and red desert loams usually highly calcareous, often skeletal lithosols.

Structure: Dense to sparse low shrubs to 1.5 m high, frequently with emergent small trees.

Canopy species: *Maireana pyramidata*, *M. astrotricha* (especially near rock outcrops), *Atriplex vesicaria* ssp. *calicicola*, emergent *Casuarina pauper* and *Flindersia maculosa*.

Other species: *Astrelba lappacea*, and various annual *Sclerolaena* spp.

Merges with: Adjoining *Astrelba lappacea* grassland, and communities dominated by combinations of *Casuarina pauper* and *Flindersia maculosa* on gibber plains and slopes.

Map unit 38

Eragrostis australasica–*Muehlenbeckia florulenta* herbland

(Canegrass–Lignum)

Geographic distribution: Widespread across entire map area, always associated with drainage lines and depressions: for example, these areas include and are mapped for the Bulloo River overflow country, extensive areas along the Paroo River and associated tributaries, scattered occurrences south of Wilcannia and isolated patches near the Warrego River.

Landforms: Seasonally flooded alluvial plains with associated channels and depressions, seasonally flooded run-on areas and internally draining basins within sandplains.

Soils: Grey clays, sometimes self-mulching.

Structure: Dense to open herbland to 3 m tall, but often only 1 m tall. Height depends partially on flood frequency and also on previous management. May be emergent small trees and shrubs.

Eragrostis australasica forms dense almost impenetrable tussock grasslands to 2 m high. Plants are frequently partially submerged with water. During long droughts, the plants gradually die, becoming grey in colour and leaving persistent culms. Individuals of *Muehlenbeckia florulenta*, Lignum, grow 2–3 m tall, but are often much smaller. They form more or less globular, tangled bushes which may be isolated or contiguous. In the latter case, they may form almost impenetrable thickets.

Canopy species: *Eragrostis australasica*, *Muehlenbeckia florulenta*, *Atriplex nummularia*. Emergents *E. largiflorens*, *A. stenophylla*, and *E. ochrophloia*.

Other species: Various shrubs including *Eremophila bignoniiflora*, *Acacia salicina*, *Chenopodium nitrariaceum*, *C. auricomum*, and *Atriplex nummularia*. The rare grasses *Uranthoecium truncatum* and *Eriochloa australiensis* grow in pans with Canegrass–Lignum herbland when the pans are full of water.

Ground cover is normally dependent on the length of time since the depression held water. Various herbs colonise the depressions following the

receding water: *Sclerolaena* spp., annual *Atriplex* spp., *Osteocarpum acropterum* var. *acropterum* and the fern *Marseilia drummondii*. Other herbs include *Centipida cunninghamii*, *Minuria cunninghamii*, *Agrostis avenacea*, *Gnaphalium luteo-album*, *Eragrostis setifolia*, *Verbena supina*, *Sclerolaena muricata* and *Diplachne fusca*. The sedges *Eleocharis pallens* and *Schoenoplectus validus* are common.

Although the dominants require regular flooding, inundation for long periods will kill *Muehlenbeckia florulenta* and convert the community into one of annual and ephemeral herbs until the next cohort of Lignum assumes dominance. In one example on the Paroo Overflow, Lignum was killed in the 1976 flood and has still not recolonised the plain.

Merges with: All communities bordering drainage lines and depressions on gentle slopes.

Map unit 39

Astrelba lappacea grassland

(Curly Mitchell Grass on floodplains)

Geographic distribution: These perennial grassland communities are widespread along the floodplains of the northern Darling River and tributaries.

Landforms: Low-lying areas subject to periodic flooding.

Soils: Grey clay soils.

Structure/main species: *Astrelba lappacea* forms dense often monospecific stands of tussock grass to 90 cm tall with an upright tufted habit (Fig. 16). It suffers from severe disturbance such as fire, drastic overgrazing and trampling. The seeds were used by Aborigines, who ground them to produce an edible paste. Mitchell grasses are important components of native grasslands and provide drought reserves for grazing.

Other species: These communities may be interspersed with *Atriplex vesicaria*–*Maireana pyramidata* communities and occasionally with *Acacia victoriae*. *Maireana aphylla* and *Chenopodium auricomum* may also be present. The communities are usually treeless, although they may intergrade with *Eucalyptus largiflorens* and *E. coolabah* subsp. *coolabah* communities.

Ground cover species include *Eragrostis setifolia*, *Dichanthium sericeum*, *Iseilema membranaceum*, *Aristida anthoxanthoides*, *Chloris truncata*, *Sclerolaena biflora*, *Sclerolaena divaricata*, *Helipterum uniflorum* and *Swainsona phacoides*.

This community sometimes grows in a mosaic with *Atriplex vesicaria* (Map unit 35). After a series of years of summer-dominated rainfall, the Mitchell Grass can become more prominent.

Map unit 40***Astrebla* grassland**

(Mitchell Grass on downs)

Geographic distribution: Discontinuous areas from north of White Cliffs to Tibooburra.

Landforms: Extensive stony and alluvial plains, low slopes, some gilgai areas.

Soils: Soils are typically red-brown sandy loams of the stony downs country. Some self-mulching brown clays.

Structure: Tussock grassland with marked seasonal variation. Considerable spatial variation on patterned ground of gillgais and associated rises.

Canopy species: *Astrebla pectinata* is the most common species, whilst *A. lappacea*, *A. elymoides* and *A. squarrosa* also occur but in decreasing order of abundance. Emergent *Maireana aphylla*, *M. pyramidata* and *Atriplex vesicaria* can occur.

Other species: Very wide range of ephemeral and annual species occurring after seasonal rain, especially *Sclerolaena* spp. After a series of summer-dominant rainfall years the Mitchell Grass predominates, but after a series of winter-dominant rainfall years chenopods may predominate. During the chenopod phase, *Atriplex* species such as *A. angulata*, *A. leptocarpa*, *A. conduplicata* and *A. lindleyi* become more obvious together with *Sclerolaena* spp. and *Osteocarpum* spp. (S. Jacobs pers. comm.)

Merges with: Other communities occurring on low angle slopes of gibber soils.

Map unit 41**Salt lakes**

Geographic distribution: Discontinuously north and west from Cobar.

Landforms: Large and small lakes which retain water for long periods when filled, e.g. > 12–15 months (Fig. 17).

Soils: Varies from saline clays, which are often puffy as a result of high salt levels, to cracking clays with extensive crabholes.

Structure: The bases of depressions are generally bare. The margins have extremely variable communities depending on salinity, slope and period since last inundation. These are mainly seasonal herbland strand communities that follow the receding water line.

Canopy species: Extremely variable.

Other species: Characteristic species include *Heliotropium curassavicum*, *Mimulus repens*, *Morgania floribunda*, *Bergia ammannioides*, *Glinus ammannioides* and *Swainsona* spp. Some saline areas may have perennial shrubs of *Halosarcia* spp. and *Sclerostegia* spp. (S. Jacobs pers. comm.).

Merges with: *Eragrostis australasica*–*Muehlenbeckia florulenta* herbland and other communities of alluvial plains.

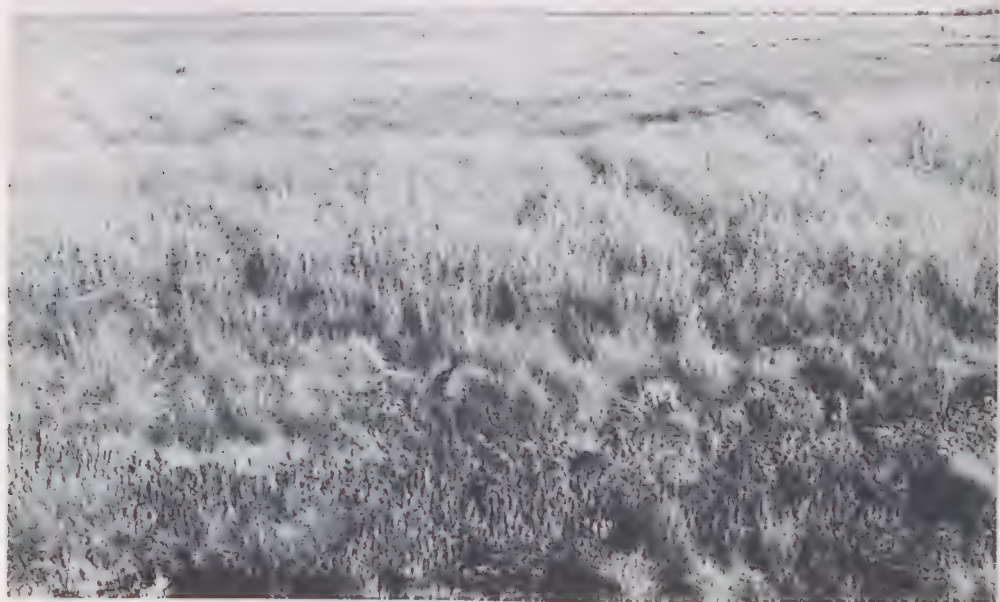


Figure 16. *Astrebla lappacea* grassland (Map unit 39). 30 km north-east of Tilpa (30° 22' S 144° 15' E).



Figure 17. Salt lake communities (Map unit 41). The Salt Lake, approximately 100 km south of Tibooburra (30° 07' S 142° 05' E).

Artesian mound springs and *Eriocaulon carsonii*

By far the most unusual and rare habitats in the map area are the artesian mound springs on the eastern and western sides of Peery Lake east of White Cliffs. These springs are still flowing despite drawdown in artesian waters caused by a century of overuse and waste. The western springs are now unique in NSW because they have the only known population of the sedge *Eriocaulon carsonii*. This species is restricted to a single mound on the western side of Peery Lake. Nearby are numerous other apparently similar mounds which do not support the plant. The springs have been heavily used for European management for over 100 years and are heavily grazed by domestic and feral stock. At least one spring was tapped for a permanent water supply, but this is now derelict. The mound with *E. carsonii* is submerged by the waters of Peery Lake for up to 18 months, apparently without harm (Pickard 1992 a, b, c, d).

Management proposals in Pickard (1992 b) include fencing off the springs with stainless steel wire and posts to minimise damage to the fence from rusting when the lake is full, and sinking a new bore to replace the springs as a water source. Another recommendation suggests research into propagation of the plant. The recommended program involves the grazier as an integral component of the plan.

A survey of all mound springs in the Western Division (Pickard 1992 d) indicates that very few are suitable habitat for introducing *E. carsonii*. Indeed, there is no evidence that the plant ever occurred on any other spring except the now extinct Wee Watta Spring north-west of Tilpa.

Conservation areas

Since European settlement virtually all of the Western Division has been subjected to the trampling of hard-footed stock or feral animals and the grazing and browsing of these introduced herbivores (Denny 1987, Benson 1988, 1991, Mitchell 1991, Morgan & Terrey 1992, National Parks Association of NSW 1988, Pressey 1990, Pressey et al. 1990).

Most of the land in the Western Division is publicly-owned leasehold administered by the Western Lands Commission. However, some portions come under the control of the NSW National Parks & Wildlife Service and the Forestry Commission of NSW.

National Parks, Nature Reserves and Historic Sites

The National Parks and Wildlife Service of New South Wales administers three National Parks, nine Nature Reserves and two Historic Sites within the map area where adequate conservation of the plant and animal communities is ensured (Fig. 15). The total area of these (Table 2) is approximately 721,440 ha, representing 2.7% of the map area.

Forest Preserves

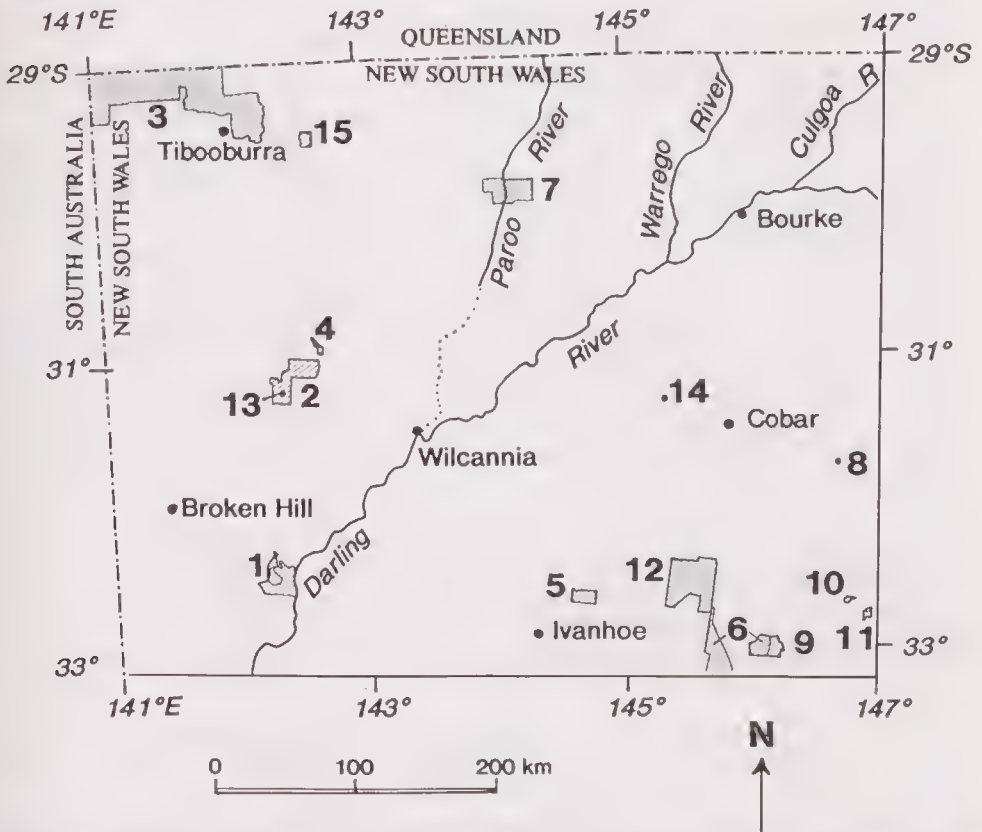
Forest Preserves are under the control of the Forestry Commission of New South Wales. The tenure of Forest Preserves has no legislative backing, whereas Flora Reserves can only be revoked by an Act of Parliament. Until Forest Preserves are established as Flora Reserves their conservation is not guaranteed.

Scrubby Mountain Forest Preserve (F.P. No. 252 in Balowra State Forest) in the Cobar district is the only Forest Preserve within the map area. It comprises sedimentary stony hills and carries *Callitris glaucophylla* associated with *Eucalyptus populnea* subsp. *bimbil*, *Eucalyptus intertexta*, *Eucalyptus sideroxylon* and *Eucalyptus microcarpa* (narrow-leaved form), plus the mallee species *Eucalyptus socialis*, *Eucalyptus dumosa*, *Eucalyptus viridis* and *Eucalyptus morrisii*. The area has had little human disturbance for a long period (Forestry Commission of NSW 1989).

Table 2. National Parks, Nature Reserves and Historic Sites within the map area (data from Property Services, NPWS, Sydney)

	Name	Area (ha)
National Parks (NP)	1. Kinchega NP	44,182
	2. Mootwingee NP	68,912
	3. Sturt NP	310,634
Nature Reserves (NR)	4. Coturaundee NR	6,688
	5. Kajuligah NR	13,660
	6. Nocoleche NR	74,000
	7. Nombinnie NR	70,000
	8. Quanda NR	854
	9. Round Hill NR	13,630
	10. Tollingo NR	3,232
	11. Woggoon NR	6,565
	12. Yathong NR	107,240
Historic Sites (HS)	13. Mootwingee HS	486
	14. Mount Grenfell HS	1,357
Total area		721,440

Figure 18. Location of National Parks, Nature Reserves, Historic Sites and Aboriginal Area.



National Parks 1. Kinchega; 2. Mootwingee; 3. Sturt; **Nature Reserves** 4. Coturaundee; 5. Kajuligah; 6. Nombinnie; 7. Nocoleche; 8. Quanda; 9. Round Hill; 10. Tollingo; 11. Woggoon; 12. Yathong; **Historic Sites** 13. Mootwingee; 14. Mount Grenfell. **Aboriginal Area** 15. Pindera Downs.

Potential problems in vegetation management

Grazing by domestic stock

Grazing started in the Western Division in the 1850s and has continued to the present. There is no doubt that grazing, past and present, is the single most important influence on the landscape. The magnitude of the impact cannot be overstated. Further, given that the bulk of the land is leased in perpetuity for grazing, the future of the landscape is intimately tied to future grazing management. This has important implications for conservation and is discussed further below. There is abundant evidence that current levels of grazing continue to have detrimental effects on the vegetation. Before considering the arguments advanced to support this assertion, it is necessary to briefly review changes in the vegetation, environment and management of the area. The information presented includes summarised field evidence collected between Wilcannia and White Cliffs (Pickard 1990a, 1990b, 1991a, 1991b, 1994, in press b).

The first graziers to settle the semi-arid rangelands found what they considered to be limitless feed. The only restriction to their operations was water. Once they augmented the few permanent waterholes with dams and wells, they simply kept on increasing

stock numbers. At the same time, seasons continued with good rainfall. Unfortunately, the graziers had confused high standing biomass with high productivity. The low productivity of the vegetation was unable to cope, and the enormous numbers of stock led to widespread devastation of vegetation, erosion, and siltation. At the same time, economic depression wiped out the markets for wool. The net result was both ecological and financial ruin (Royal Commission 1901). At the end of the 19th century, stock numbers had fallen from their peak, never to rise to such heights again.

For the next several decades, the landscape bore the scars of the pioneers' management: enormous scalds, dust storms, little regeneration, etc. (Holmes 1938, Beadle 1948). Seasons were generally poor, with low rainfall. The landscape and the vegetation continued in the state left by the damage of the 19th century.

After the Second World War, things changed: higher rainfall, better financial returns, more investment in improvements, more intensive management, better transport systems, and for the first time, effective control of rabbits. At the same time, the landscape began to heal: scalds reduced in number and area, dust storms receded and some regeneration occurred (Condon 1986, Palmer 1991). That these changes have occurred is not open to dispute; but the cause is, and this is quite critical to the future management of the vegetation. There are three main arguments presented to account for the changes.

The first, and the argument most favoured by graziers, is that management has improved enormously since World War II and with more watering points and fences, and with control of rabbits, grazing has less impact than previously (Palmer 1991). Even acknowledging the benefits of rabbit control, the other factors in this argument are difficult to support when all available evidence is examined (Pickard 1991c, 1994). There is still very little or no regeneration of palatable shrubs over enormous areas.

The second argument, supported only by Condon (1986), asserts that changes in legislation and administration of the land through closer settlement is the main cause. There is very little evidence to support this claim.

The third argument suggests that increased rainfall since 1947 has been the primary factor with secondary assistance from rabbit control. This accounts for the fact that stock numbers over large areas have increased since then at the same time that scalds have regenerated naturally. This would only be possible if there was more feed to support the stock (Pickard 1990a, 1994).

This debate is crucial to the future of the vegetation. The root of the disagreement lies in what is considered acceptable damage to the landscape, and what levels of stocking are acceptable. It is likely that many graziers are unaware of the more subtle changes that have taken place. Everyone can see, recognise and understand the impact of scalds and "woody weed" invasion. But how many graziers are aware that losing the top 5 cm of soil in *Acacia aneura* shrubland results in the loss of the bulk of the nutrients (Pressland et al. 1988)? A soil loss of 5 cm would not be detected by most graziers. Yet this is the magnitude of loss that probably still occurs as a consequence of grazing at currently accepted levels in the Western Division.

Although overstocking is prohibited under the Western Lands Act (s. 18D 1 v), there were numerous examples of overstocking during the 1991–1992 drought. Anecdotes relate how thousands of sheep died from starvation. This will only occur if there is no feed available: by definition, this is overgrazing. However, while this may have a severe and long-lasting impact on the soil through erosion and sedimentation, its impact on vegetation may be exaggerated (see below).

The impact of herbivores is not uniform across the semi-arid landscape. Favoured areas of high productivity are grazed more heavily. These areas probably supported the highest populations of native fauna before European settlement (Stafford Smith &

Morton 1990). The disruption and destruction of these habitats has had serious impacts on fauna (Morton 1990).

Regeneration of palatable canopy species

Traditionally it is assumed that present grazing is relatively benign compared to grazing at the end of the 19th century. Proponents of this view argue that the vegetation was devastated by vast numbers of stock to generate enormous profits for rapacious absentee owners (Palmer 1991). However, as noted above, palatable shrubs are not regenerating over most of the map area. Thus current grazing levels are too high to guarantee the long-term future of most of the vegetation (Pickard in press b). Consequently, unless there are fundamental changes in grazing regimes, it is not possible to guarantee long-term survival of the vegetation and landscape. Effects of present (and past) regimes on native fauna (both vertebrate and invertebrate) are also significant and of course relevant to vegetation and ecosystems at large.

It is crucial to realise that rainfall has essentially no influence on the outcome, and that these are not seasonal effects to be dismissed by graziers and their organisations with assertions such as: "It's the drought mate. This is good country. She always comes back after decent rain." There is abundant evidence to show that these are long-term effects over decades covering both good as well as bad seasons. Three examples will suffice here. For others, see the studies quoted in Pickard (1991c). Over at least three decades, *Acacia papyrocarpa* has only regenerated in semi-arid South Australia where seedlings are protected from both sheep and rabbits. *Casuarina pauper* and *Alectryon oleifolius* did not regenerate in south-western NSW despite heavy rains in the 1970s. The available evidence suggests that rabbits and sheep are eliminating all young plants.

Current damage to the flora and vegetation is independent of rainfall. The common link over a wide geographic range is grazing by sheep and feral animals, especially rabbits. The root cause is too many herbivores trying to survive on low-productivity land. Consequently, grazing at currently accepted and acceptable levels is the single major problem facing semi-arid Australia (Pickard in press b).

The basic issue with grazing management is simple and can be reduced to very few words: too little feed, too many mouths. Like many environmental problems, the technical aspect of the solution is trivial: reduce the number of mouths. But because of a complex web of personal, financial and political reasons, the social aspects of the solution appear intractable.

There is now increasing evidence that comparatively low stocking rates actually increase net income while encouraging land regeneration (Purvis 1986, Morrissey & O'Connor 1988). The impact of so-called 'minimal stocking rate' systems on conservation values is unknown. However, vegetation does regenerate with these systems, and as vegetation forms the basis of the food chain for most animals, the systems are worth investigating.

In any event, there is no doubt that only a financially secure grazier can afford to be worried about conservation of non-income producing components of the landscape. Therefore it is essential to quantify these impacts over a range of environments.

Currently, the solution appears to lie in 'minimal stocking rate' grazing systems that have been developed by graziers (Purvis 1986, Morrissey & O'Connor 1988). While these have been shown to generate more income for the grazier, their impact on conservation of the landscape is unknown.

"Woody weeds"

Substantial increases in numbers and density of several species have earned them the pejorative expression "woody weeds": unpalatable native shrubs (e.g. *Senna artemisioides*, *Dodonaea viscosa* ssp. *angustifolia*, *Dodonaea viscosa* ssp. *angustissima*, *Eremophila mitchellii*, *Eremophila sturtii*). It is generally accepted that these are a form of land degradation because they lower production in terms of sheep, wool, lambing percentages, and profitability (Burgess 1988). While there is some evidence that soil erosion may be higher in dense stands of "woody weeds", there is very little evidence that they are causing any problem with respect to biodiversity.

It is generally considered that "woody weeds" have increased in density because of the lack of regular fire. Domestic stock have removed all the available biomass (fuel) and thus there are now fewer fires than before European settlement (Booth 1985). Thus the plants are responding to a radically changed environment, and are a consequence of grazing. (There is growing field and experimental evidence in Texas, USA, that similar species there are responding to increased CO₂ levels in the atmosphere since the mid-19th century (Johnson et al. 1992, Mayeux et al. 1992, Bahre 1991). If this is the case, then "woody weeds" are in fact, the new vegetation of a large proportion of the semi-arid landscape.)

Environmental weeds

Many exotic plants occur in the map area, but only a relatively small number can be regarded as serious invaders. Perhaps the most serious environmental weed (Humphries 1992) is *Prosopis* spp. (Mesquite). The spiny shrub is mainly located from Broken Hill north to Packsaddle, but has also been recorded from the floodplain of the Darling River southeast of Wilcannia. However, the species occupies hundreds of square kilometres in the upper catchment of the Paroo River in Queensland. Seeds will be carried downstream by floods and will eventually spread into the lower Paroo in New South Wales. Once established, the plant forms dense impenetrable thickets in all suitable habitats. Creek lines and alluvial plains are favoured habitats. As seeds last up to 40 years in the soil, once the species occurs in an area, it is almost impossible to eradicate. *Prosopis* is (barely) controlled with herbicides and is currently listed nationally as a target for biological control.

Lycium ferocissimum (African Boxthorn) is widespread on scalded plains east of White Cliffs, near Ivanhoe and elsewhere, and often close to old watering points on sand-plains. The spiny shrub spreads via seeds in bird droppings and in flood debris. Once established, it can form dense thickets, but plants are killed by prolonged droughts (e.g. 1991–1992 drought). When abundant, the plant completely changes the structure of the vegetation. Thus, low open-shrublands of *Maireana* spp. are transformed into *Lycium* Open-shrublands. *Lycium* may have some value as a nesting site for small birds which appear to find shelter from predators in the dense spiny shrubs, and even when dead, the shrubs afford considerable protection.

Xanthium spinosum (Bathurst Burr) and *Carthamus lanatus* (Saffron Thistle) are widespread roadside weeds spreading into suitable sites. *Xanthium* is generally restricted to wetter areas, such as ephemeral creeks. In favourable (wet) seasons, local populations may be extremely dense, and set abundant seed to maintain the infections. In contrast, *Carthamus* is more widespread in drier sites and has been gradually spreading in the area for the past few decades. It is most often seen as dead plants, but the seeds are very long-lived and thus, once established, the plant can quickly appear from seeds in the soil when suitable moisture conditions prevail. Currently there is virtually no systematic attempt at controlling either species. Given the relative values of the land, cost of control, and anticipated benefits from control, concerted efforts at control are unlikely.

Conservation options for future management of the vegetation

Alternative approaches to vegetation management for conservation

In the Western Division the approach of the NSW National Parks and Wildlife Service has been to acquire land with perceived high conservation values, though some land has been acquired merely because it was vacant. An important aim is to have one sample of every land system in a formal reserve. This is one of the most popular objectives of conservationists, but is probably politically unlikely (Pressey & Nicholls 1989). For this, and other cogent reasons, it is apparent that formal conservation areas need to be complemented by off-reserve conservation procedures to achieve goals of environmental conservation. Such procedures include negotiating agreements with landholders whose land covers sites deemed to be of high conservation value — for example the proposals recommended to conserve the rare *Eriocaulon carsonii* discussed above. Such negotiations could conclude with a range of measures that satisfy both the conservation objectives and the aspirations of the landholder: formal contracts, informal agreements, covenants on titles, and combinations of these. The landholder should be compensated in an appropriate manner for foregone income.

However, the implications of the findings of Pressey & Nicholls (1989) should be noted. Piecemeal attempts at reserving examples of environments are not the best approach. Instead all options for the Western Division need to be addressed as a whole. There are problems with this. When the National Parks and Wildlife Service seeks to purchase properties in the Western Division, particularly during periods of rural depression, it is perceived by remaining graziers as being opportunistic. Interestingly, other purchasers would not be regarded in this light, demonstrating a double standard among graziers. Further, potential problems caused by graziers being financially unable to maintain improvements over the past few years have been ignored by neighbours. As soon as the Service acquired any land, these would immediately jump to prominence and may be considered the fault of the Service. There are no easy solutions to these problems. They are merely the corollary of acquiring land for environmental conservation.

Currie & Hacker (1990) argue that in arid Western Australia grazing may be compatible with conservation. There is however a dearth of relevant information on the impact of different grazing systems and styles of management on the vegetation of semi-arid NSW. Some semi-arid lands in South Australia are currently managed for multiple uses; grazing, recreation, mining and conservation (Cohen 1990). Experience to date has been promising despite some initial problems. Legislation in the United States requires multiple use of Federal land for grazing, logging, recreation and conservation (Clawson 1983). In principle, each parcel is considered to determine which use should be given priority. In practice, existing grazing use is often given preference (Jacobs 1991).

Combining these arguments with those expounded earlier, it is clear that successful off-reserve conservation is predicated on both successful negotiations (every party wins and achieves their own goals), and landscape management that is sensitive to conservation objectives. In general terms it is known (and accepted by most graziers, and all agencies) that excessively heavy grazing leads to land degradation; soil erosion, vegetation structure changes, and perhaps "woody weed" invasion. What is not so widely accepted is that grazing levels that are currently considered to be safe are also causing land degradation (Pickard 1991a, c).

Before being involved in off-reserve conservation on their properties, graziers need to be convinced that they will not suffer financially. As the normal approach suggested is to lower stocking rates, this does not appear very convincing to many graziers

(Pickard in press b). However, there is now increasing evidence that comparatively low stocking rates actually increase net income while encouraging land regeneration (Purvis 1986, Morrissey & O'Connor 1988). The impact of these 'minimal stocking rate' systems on conservation values is unknown but it is essential to quantify these impacts over a range of environments.

Acknowledgements

The data presented in this report and represented on the map were collected over many years. Pickard's field visits to the area from 1970 to 1978 to map the vegetation were funded by the National Herbarium of New South Wales. Study in the mid-to late 1980s was supported by the Western Lands Commission. Field work and other research in the White Cliffs area in the late 1980s and early 1990s has been funded by grants administered through Macquarie University: Australian Research Grants (Small Grant), Macquarie University Research Grant and two National Estate Grants. Other data were collected during contract from NSW National Parks & Wildlife Service to prepare a species management plan for *Eriocaulon carsonii*.

The authors wish to thank Lawrie Johnson, Surrey Jacobs, Ken Hill and Doug Benson for commenting on the manuscript and Barbara Briggs and the Royal Botanic Gardens for supporting the project. Thank you to Phil Lindsay, Helen Bryant and botanists at the National Herbarium of NSW for assistance with field trips and plant identification. Judy Scott drafted the figures and Jocelyn Howell assisted with this and typing.

The graziers and their families in the area have allowed access to their properties, provided hospitality and information over many years. Without their assistance, the vegetation map could not have been prepared.

References

- Allen, R.H. (1980) Aborigines of the western plains of New South Wales. *Parks and Wildlife* 2:33-42.
- Australian Bureau of Statistics (1991) Estimated Resident Population of Statistical Local Areas, New South Wales, at 30th June, 1989 Final and 1990 Preliminary.
- Australian Water Resources Council (1972) Hydrology of smooth plainlands of arid Australia. *Hydrological Series* No. 6. (Australian Government Publishing Service: Canberra).
- Bahre, C.J. (1991) *A legacy of change. Historic human impact on vegetation of the Arizona borderlands.* (University of Arizona Press: Tucson).
- Bailey, A. (ed.) (1984) *The brigalow belt of Australia.* (Royal Society of Queensland).
- Beadle, N.C.W. (1948) *The vegetation and pastures of western New South Wales with special reference to soil erosion.* (Government Printer: Sydney).
- Beadle, N.C.W. (1981a) *Vegetation of Australia.* (Cambridge University Press: Melbourne).
- Beadle, N.C.W. (1981b) Forty years ago. *Cunninghamia* 1: 1-6.
- Beard, J.S. (1974) *Great Victoria Desert. Vegetation Survey of Western Australia 1:1 000 000 Vegetation Series.* (University of Western Australia Press: Nedlands).
- Beard, J.S. & Webb, M.J. (1974) *Great Sandy Desert. Vegetation Survey of Western Australia 1: 1 000 000 Vegetation Series.* (University of Western Australia Press: Nedlands).
- Beetson, G.R., Walker, P.J., Purdie, R. & Pickard, J. (1980) Plant communities of the poplar box (*Eucalyptus populnea*) lands of eastern Australia. *Australian Rangeland Journal* 2(1): 1-16.
- Benson, J.S. (1988) Conservation of flora in western New South Wales. *National Parks Journal* 32(3): 16-22.
- Benson, J.S. (1991) The effect of 200 years of European settlement on the vegetation and flora of New South Wales. *Cunninghamia* 2(3): 343-370.
- Booth, C.A. (1985) *Woody weeds: their ecology and control.* (Soil Conservation Service of NSW: Sydney).

- Boyland, D.E. (1974) Vegetation. In Western arid region land use study — part 1. *Division of Land Utilisation Tech. Bulletin No.12*. (Queensland Dept. of Primary Industries: Brisbane).
- Boyland, D.E. (1984) Vegetation survey of Queensland — south-western Queensland. *Queensland Botany Bulletin* No. 4. (Queensland Dept. of Primary Industries: Brisbane).
- Bowler, J.M. (1971) Pleistocene salinities and climatic change: evidence from lakes and lunettes in south-eastern Australia. In Mulvaney, D.J. & Golson, J. (eds), *Aboriginal man and environment in Australia* (ANU Press: Canberra).
- Bureau of Meteorology (1988) *Climatic Averages: Australia*. (Australian Government Publishing Service: Canberra).
- Burgess, D.M.N. (1988) The economics of prescribed burning for shrub control in the semi-arid woodlands of north-west New South Wales. *Australian Rangeland Journal* 10: 48–59.
- Burrell, J.P. (1973) Vegetation of Fowlers Gap Station. In Lands of Fowlers Gap Station, New South Wales. J.A. Mabbutt (ed.) *University of NSW Research Series No.3*: 175–195.
- Cambage, R.H. (1900a) Notes on the botany of the interior of New South Wales. I. From the Darling River at Bourke to Cobar. *Proceedings of the Linnean Society of NSW* 25: 591–604.
- Cambage, R.H. (1900b) Notes on the botany of the interior of New South Wales. II. From Cobar to the Bogan River above Nyngan. *Proceedings of the Linnean Society of NSW* 25: 708–720.
- Clawson, M. (1983) *The federal lands revisited*. (Resources for the Future: Washington).
- Cohen, B. (1990) Reconstruction of South Australia's arid lands: the conservation option. *Proceedings of the Ecological Society of Australia* 16: 459–465.
- Collins, M.I. (1923) Studies in the vegetation of arid and semi-arid New South Wales. I — the plant ecology of the Barrier District. *Proceedings of the Linnean Society of NSW* 48: 229–266.
- Collins, M.I. (1924) Studies in the vegetation of arid and semi arid New South Wales. II — the botanical features of the Grey Range and its neighbourhood. *Proceedings of the Linnean Society of NSW* 49: 1–18.
- Condon, R.W. (1976) History of administration of the Western Division. *Agricultural Gazette of N.S.W.* 87: 2–5.
- Condon, R.W. (1986) Recovery of catastrophic erosion in western New South Wales. In Joss, P.J., Lynch, P.W. & Williams, O.B. (eds) (1986) *Rangelands: a resource under siege*. (Cambridge University Press: Cambridge).
- Cunningham, G.M. & Milthorpe, P.L. (1981) The vascular plants of five exclosure sites in western New South Wales. *Cunninghamia* 1: 23–34.
- Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. & Leigh, J.H. (1981) *Plants of Western New South Wales*. (Government Printer: Sydney).
- Currie, P.J. & Hacker, R.B. (1990) Can pastoral grazing management satisfy endorsed conservation objectives in arid Western Australia? *Journal of Environmental Management* 30: 295–320.
- Dalton, K.L. (1988) A review of information relevant to the Downs Country of far western New South Wales. *Soil Conservation Service of NSW Technical Report No. 11*.
- Dawson, N.M. & Boyland, D.E. (1974). Western arid region land use study — part 1. *Division of Land Utilisation Tech. Bulletin No.12*. (Queensland Dept. of Primary Industries: Brisbane).
- Denny, M. (1987) *Historical and ecological study of the effects of European settlement in inland NSW*. Report by the Nature Conservation Council of New South Wales to the Heritage Council of New South Wales.
- Eldridge, D.J. (1988) Soil-landform and vegetation relations in the chenopod shrublands of western New South Wales. *Earth Science Reviews* 25: 493–499.
- Forestry Commission of NSW (1989) Forest preservation in state forests of New South Wales. *Research Note* no 47.
- Fox, M.D. (1991) The natural vegetation of the Ana Branch — Mildura 1: 250 000 map sheet (New South Wales). *Cunninghamia* 2(3): 443–494.
- Gentili, J. (ed) (1971) *Climates of Australia and New Zealand. World survey of climatology*. Vol 13. (Elsevier Publishing Company: Amsterdam).
- Geological Survey of NSW (1972) *Geology of New South Wales*. 1:1 000 000 Map.
- Groves, R.H. (ed.) (1981) *Australian vegetation*. (Cambridge University Press: Cambridge).
- Harden, G.J. (ed.) (1990–1993) *Flora of New South Wales* Vols.1–4 (New South Wales University Press: Sydney).
- Harris, C.R. 1989. The history of mallee land use: Aboriginal and European. In: J.C. Noble, P.J. Joss & G.K. Jones *The mallee lands — a conservation perspective*. Proceedings of the National Mallee Conference, CSIRO.
- Haviland, F.E. (1911) Notes on the indigenous plants in the Cobar district. *Proceedings of the*

- Linnean Society of NSW* 36: 507–540.
- Haviland, F.E. (1913) Notes on the indigenous plants in the Cobar district. No ii. *Proceedings of the Linnean Society of NSW* 38: 639–655.
- Hill, K.D. (1989) Mallee eucalypt communities: their classification and biogeography. In: J.C. Noble & R.A. Bradstock (eds) *Mediterranean landscapes in Australia — mallee ecosystems and their management*. (CSIRO Publications: East Melbourne).
- Holmes, J.M. (1938) The erosion-pastoral problem of the Western Division of New South Wales. *University of Sydney Publications in Geography* 2: 1–51.
- Humphries, S.E. (1992) Plant invasions: The incidence of environmental weeds in Australia. *Kowari* 2: 1–134.
- Irons, N.M. & Quinlan, E.E. (1988) A review of information relevant to the Mulga rangelands of western New South Wales. *Soil Conservation Service of New South Wales Technical Report* No. 5.
- Isbell, R.F. (1962) Soils and vegetation of the Brigalow Lands of Eastern Australia. *CSIRO Soils and Land Use Series* No. 43.
- Iwaszkiewicz, A. & Semple, W.S. (1988) A review of information relevant to the Bimble Box-Pine and associated rangelands of western New South Wales. *Soil Conservation Service of N.S.W. Technical Report* No. 6.
- Jacobs, L. (1991) *Waste of the west: public lands ranching*. (Lynn Jacobs: Tucson).
- James, J.W. (1960) Erosion survey of the Paroo–Upper Darling region. Part III — Vegetation. *Journal Soil Conservation Service NSW* 16: 185–206.
- Johns, G.G., Tongway, D.J. & Pickup, G. (1984) Land and water processes. In *Management of Australia's rangelands*. (CSIRO Division Wildlife and Rangelands Research: East Melbourne).
- Johnson, H.B., Polley, W.P. & Mayeux, H.S. (1992) Increasing CO₂ and plant–plant interactions: effects on natural vegetation. *Vegetatio* **, 1–16.
- Johnson, R.W. (1984) Flora and vegetation of the Brigalow Belt. In: A. Bailey (Ed.) *The brigalow belt of Australia*. (Royal Society of Queensland: Brisbane).
- King, C.J. (1957) An outline of closer settlement in New South Wales. Part 1 — The sequence of the land laws 1788–1956. *Review of Marketing and Agricultural Economics* 25:9–29.
- Lawrie, J.W. (1976) Landforms, soils and erosion. *Agricultural Gazette of New South Wales* 87(3):13–15.
- Lawrie, J.W. (1991) Soils and erosion. In: P.L. Milthorpe *et al.* *Lands of the north-west corner of NSW. Soil Conservation Service of NSW. Technical Report* No.12.
- Mabbutt, J.A. (1973) Historical background. In *Lands of the Fowlers Gap Station, New South Wales*. J.A. Mabbutt & M.E. Sullivan (eds) *Fowlers Gap Arid Zone Research Station, Research Series* No.3 (University of New South Wales: Kensington).
- MacGillivray, W. (1923) A trip to the north and north-west from Broken Hill. *Victorian Naturalist* 39: 131–142.
- Mayeux, H.S., Johnson, H.B. & Polley, H.W. (1992) Global change and vegetation dynamics. Chapter 7, pp. 62–74 in James, L.F., Evans, J.O., Ralphs, M.H & Child, R.D. (eds) *Noxious range weeds*. (Westview Press: Boulder).
- McTainsh, G.H., Burgess, R. & Pitalbo, J.R. (1989) Aridity, drought and dust storms in Australia (1960–84). *Journal of Arid Environments* 16: 11–22.
- Milthorpe, P.L. (1972) Vegetation of the Fowlers Gap–Calindary Area. In *Lands of the Fowlers Gap–Calindary Area, New South Wales*. Fowlers Gap Arid Zone Research Series No. 4. University of New South Wales.
- Milthorpe, P.L. (1991) Lands of the north-west corner of New South Wales. *Soil Conservation Service of NSW Technical Report* No. 12.
- Mitchell, P.B. (1991) Historical perspectives on some vegetation and soil changes in semi-arid New South Wales. *Vegetatio* 91:169–182.
- Mitchell, T.L. (1838) *Three expeditions into the interior of eastern Australia ...* (T. & W. Boone: London).
- Moore, C.W.E. (1986) Annotated checklist of the vascular plants in part of north-western New South Wales. *CSIRO Technical Memorandum* 84/30. (Institute of Biological Resources, Division of Water and Land Resources: Canberra).
- Morcom, L. (No date) Expedition Sturt May 1988 Sturt National Park, New South Wales. Botany Group Report. Australian & New Zealand Scientific Exploration Society.
- Morgan, G. & Terrey, J. (1992) *Nature conservation in western New South Wales* (National Parks Association of New South Wales Inc.: Sydney).
- Morris, A. (1939) Plant regeneration in the Broken Hill district. *Australian Journal of Science* 2: 32–38.

- Morris, A. (1966) *Plantlife of the West Darling*. (Barrier Field Naturalists Club).
- Morrissey, J.G. and O'Connor, R.E.Y. (1988) 28 years of station management. Paper presented to 5th Biennial Conference of the Australian Rangeland Society, Longreach, Queensland.
- Morton, S.R. (1990) The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. *Proceedings of the Ecological Society of Australia* 16: 201–213.
- National Parks Association of NSW (1988) Nature conservation in western New South Wales. Special Issue. *National Parks Journal* 32(3).
- National Parks & Wildlife Service (1982) Submission to joint select committee enquiry on the Western Division of New South Wales.
- Neldner, V.J. (1984) *Vegetation survey of Queensland: South central Queensland*. Queensland Botany Bulletin No 3. (Queensland Dept of Primary Industries).
- Noble, J.C. (1982) The significance of fire in the biology and evolutionary ecology of mallee *Eucalyptus* populations. In W.R. Barker & P.J.M. Greenslade (eds) *Evolution of the flora and fauna of arid Australia* (Peacock Publications: Adelaide).
- Noble, J.C. (1984) Mallee. In G.N. Harrington, A.D. Wilson & M.D. Young *Management of Australia's rangelands* (CSIRO Division of Wildlife and Rangelands Research: Melbourne).
- Noble, J.C., Joss, P.J. & Jones G.K. (eds) (1990) *The mallee lands — a conservation perspective*. CSIRO.
- Packham, G.H. (1969) *The geology of New South Wales*. (Geological Society of Australia: Sydney).
- Palmer, D. (1991) Western New South Wales — a miracle of recovery. *Australian Journal of Soil and Water Conservation* 4: 4–8.
- Parson, A. (1990) Conservation and ecology of riparian communities in the Murray–Darling Basin, New South Wales. Annotated Bibliography — Preliminary version 2. (Unpubl. report National Parks & Wildlife Service: Sydney)
- Parson, A. (1991) Conservation and ecology of riparian communities in the Murray–Darling Basin, New South Wales. Review Draft January 1991. (Unpubl. report National Parks & Wildlife Service: Sydney).
- Pickard, J. (1983) Vegetation of Lord Howe Island. *Cunninghamia* 1(2): 133–266.
- Pickard, J. (1990a) Analysis of stocking records from 1884 to 1988 during the subdivision of Momba, the largest property in semi-arid New South Wales. *Proceedings of the Ecological Society of Australia* 16: 245–253.
- Pickard, J. (1990b) Attitudes and environmental use and management in the forgotten 70% of Australia. *Australian Zoologist* 26: 54–58.
- Pickard, J. (1991a) Land management in semi-arid environments of New South Wales. *Vegetatio* 91: 191–208.
- Pickard, J. (1991b) Quaternary studies and land rehabilitation in semi-arid New South Wales; or when is a scald not a scald? In Brierley, G. & Chappell, J.M.A. (eds) *Applied Quaternary studies*. (Department of Biogeography and Geomorphology, Australian National University: Canberra).
- Pickard, J. (1991c) Sheep and rabbits: the biological chainsaws. *Search* 22: 48–50.
- Pickard, J. (1992a) Recovery plan research phase. *Eriocaulon carsonii*. Final report on contract with NSW National Parks & Wildlife Service.
- Pickard, J. (1992b) Conservation recovery plan, management phase. *Eriocaulon carsonii*. Final report on contract with NSW National Parks & Wildlife Service.
- Pickard, J. (1992c) Conservation research statement. *Eriocaulon carsonii*. Final report on contract with NSW National Parks & Wildlife Service.
- Pickard, J. (1992d) Mound springs of the Western Division of New South Wales. Graduate School of the Environment Occasional Paper, Macquarie University.
- Pickard, J. (1993) Western New South Wales — increased rainfall and not a miracle leads to recovery. *Australian Journal of Soil and Water Conservation* 6(4): 4–9.
- Pickard, J. (1994) Post-European changes in creeks of semi-arid rangelands, "Polpah Station", New South Wales. In Millington, A.C. & Pye, K. (eds) *Effects of environmental change in drylands*. (John Wiley: London), p. 271–283.
- Pickard, J., (in press a). Do old survey plans help us discover what happened to western New South Wales when Europeans arrived? *Australian Zoologist*.
- Pickard, J. (in press b) Land degradation and conservation in the semi-arid zone of Australia: grazing is the problem ... and the cure. in Moritz, C. (ed) *Conservation biology in Australia and Oceania* (Surrey Beatty: Chipping Norton).
- Pickard, J. & Boyland, D.E. (1981) Comparison of three small-scale (1:1 000 000) vegetation

- mapping techniques. In A.N. Gillison & D.J. Anderson (eds) *Vegetation classification in Australia*. (CSIRO: Canberra).
- Pittock, A.B. (1981) Long term climatic trends in eastern Australia. pp. 23–39 in de Krantzow, D.R. & Sutton, B.G. (eds) (1981) *Cropping at the margin: potential for overuse of semi-arid lands*. Australian Institute of Agricultural Science Symposium Series No 1.
- Porteners M. (1993) The natural vegetation of the Hay Plain: Booligal–Hay and Deniliquin–Bendigo 1:250 000 maps. *Cunninghamia* 3(1): 1–122.
- Pressey, R.L. (1990) Clearing and conservation in the Western Division. *National Parks Journal* 34(6): 16–24.
- Pressey, R.L. and Nicholls, A.O. (1989) Application of a numerical algorithm to the selection of reserves in semi-arid New South Wales. *Biological Conservation* 50: 263–278.
- Pressey, R.L., Cohn, J.S. & Porter, J.L. (1990) Vascular plants with restricted distributions in the Western Division of New South Wales. *Proceedings of the Linnean Society of NSW* 112: 213–233.
- Pressland, A.J., Mills, J.R. & Cummins, V.G. (1988) Landscape degradation in native pasture. In Burrows, W.H., Scanlan, J.C. & Rutherford, M.T. (eds) (1988) *Native pastures in Queensland. The resources and their management*. (Queensland Department of Primary Industries Information Series Q187023) 174–197.
- Pulsford, I.F. (1984) Conservation status of Brigalow in New South Wales. In A. Bailey (ed.) *The brigalow belt of Australia*. (Royal Society of Queensland: Brisbane).
- Purvis, J.R. (1986) Nurture the land: my philosophies of pastoral management in central Australia. *Australian Rangeland Journal* 8: 110–117.
- Reynolds, S.T. (1985) Sapindaceae (excluding *Dodonaea* and *Diplopeltis*). *Flora of Australia* 25: 4–164.
- Royal Commission (1901) *Royal Commission to inquire into the condition of the crown tenants of the Western Division of New South Wales*. 2 volumes (Legislative Assembly of New South Wales: Sydney).
- Sattler, P.S. (ed.) 1986. *The mulga lands: Proceedings of a Symposium*. (Royal Society of Queensland: Brisbane).
- Scott, J.A. (1992) The natural vegetation of the Balranald–Swan Hill area. *Cunninghamia* 2(4): 597–652.
- Semple, W.S. & Irons, N.M. (1989) The Rangeland Review Program: A computerised listing of references pertaining to the rangelands and rangeland plants of western New South Wales. *Soil Conservation Service of New South Wales Technical Report No. 19*.
- Soil Conservation Service of NSW (various dates) 1:250 000 *Land System Series*. Sheets: Milparinka, Cobham Lake, Broken Hill, Menindee, Urisino, White Cliffs, Wilcannia, Manara, Yantabulla, Louth, Barnato, Ivanhoe, Enngonia, Bourke, Cobar, Nymagee. (NSW Central Mapping Authority: Bathurst).
- Specht, R.L. (1972) *The vegetation of South Australia*. (Government Printer: Adelaide).
- Stafford Smith, D.M. and Morton, S.R. (1990) A framework for the ecology of arid Australia. *Journal of Arid Environments* 18: 255–278.
- Stannard, M.E. (1962) Erosion survey of the Central East-Darling region. Part II Soils. *Journal of the Soil Conservation Service of NSW* 18: 173–182.
- Stannard, M.E. (1963) Erosion survey of the Central East-Darling region. Part III Vegetation. *Journal of the Soil Conservation Service of NSW* 19: 17–28.
- Sturt, C. (1849) *Narrative of an expedition into Central Australia*. Australiana Facsimile Edn no 5 (Libraries Board of South Australia: 1965).
- Turner, F. (1903) Botany of the Darling, New South Wales. *Proceedings of the Linnean Society of NSW* 28: 406–442.
- Turner, F. (1905) Botany of north-western New South Wales. *Proceedings of the Linnean Society of NSW* 30: 32–91.
- Wade, T. (1992) *The brigalow outlier* (NSW Department of Conservation and Land Management).
- Walker, P.J. (1991) Land systems of western New South Wales. *Soil Conservation Service of New South Wales Technical Report No. 25*.
- Western Lands Commission (1990) *Western lands* (Western Lands Commission: Sydney).

Manuscript received 4 January 1993

Manuscript accepted 18 May 1993

Rainforest stands between Barrington Tops and the Hunter River, New South Wales

J.C. Turner and S.L. Vernon

Turner, J.C.¹ & Vernon, S.L.² (¹21 Tyrrell St, Newcastle, NSW, Australia 2300; ²Hunter Catchment Management Trust, High St, Maitland, NSW, Australia, 2315) 1994. Rainforest stands between Barrington Tops and the Hunter River, New South Wales. *Cunninghamia* 3(3): 465–514. The environmental settings and floristic compositions of 46 rainforest stands are examined. The stands, of total area about 850 ha, were selected from some 3 700 km² of foothill country north of the Hunter River towards the southern scarp of Barrington Tops. The surveyed stands (median area: 15 ha) have characteristics typical of the dry rainforest sub-formation: several emergents (*Ficus* spp. and *Brachychiton discolor*), rich tree and woody climber components, relatively small numbers of shrub, fern and epiphyte species, and a sparse ground stratum. They contain about 200 species, excluding grasses, sedges and eucalypts. The stands form a fairly homogeneous group, with relatively little compositional change evident across the survey area. The three most abundant and widespread tree species are (in decreasing order) *Streblus brunonianus*, *Mallotus philippensis* and *Capparis arborea*. This is the southernmost occurrence of such a large area of floristically and structurally well-developed dry rainforest. No rare or threatened plant species are known to be present, but 11 rainforest species are thought to reach their southern limits in the survey area. With one exception, the stands are in private ownership, with no legal protection from disturbance. Their current conservation status is therefore very unsatisfactory.

Introduction

Much of the remaining rainforest in NSW is now in National Parks and Nature Reserves, where it is fully protected, or in State Forests, where present policy gives most of it some protection. However, a large number of smaller stands lie outside such protection and most of them have not yet been systematically examined.

In the Hunter Valley, because of the particular patterns of rainfall, landforms and lithology, most of the remaining rainforest lies between Barrington Tops and the Hunter River (Figure 1), as did most rainforest before European settlement. All of the northern section of this tract is in the Barrington Tops National Park and in State Forests. The rainforest stands in these locations are not threatened by human activity and are relatively well known botanically (e.g. Fraser and Vickery, 1938; Bowden and Turner, 1976; Turner, 1976; Floyd, 1990). However, the lower and more southerly parts are largely in private hands and contain several hundred rainforest stands, many of them still in good condition, whose structure and composition are complementary to those of the stands in the immediate Barrington Tops area. These surviving stands are generally conspicuous in the foothill landscapes, especially because past clearing practices have often left a stand mostly untouched while the surrounding eucalypt forest has been wholly or partially removed. Although many stands have escaped wholesale clearing up to the present day, they are exposed to disturbance by cattle, fire, the invasion of weeds, and such activities as timber-getting and track construction.

Four rainforest sub-formations occur in this part of the Hunter Valley: cool temperate, warm temperate, sub-tropical and dry (Williams, Harden & McDonald 1984,

pp. 6–7). Cool temperate rainforest, above about 900 m altitude, warm temperate rainforest, immediately below 900 m, and sub-tropical rainforest in the valley floors close to the southern scarp of Barrington Tops, are almost wholly contained within the National Park and State Forests. Further south, recent examination of a few of the foothill stands mentioned above (Floyd 1983a; Vernon 1985) showed that they consist predominantly of dry rainforest, with some internal gradation towards sub-tropical rainforest.

This paper reports the results of an examination of the floristic composition and other characteristics of a sample of rainforest stands north of the Hunter River to the southern boundaries of the publicly-owned land close to Barrington Tops. The eastern boundary of the overall study area is the eastern edge of the Williams River drainage basin, and the western boundary is the western edge of the Foy Brook basin.

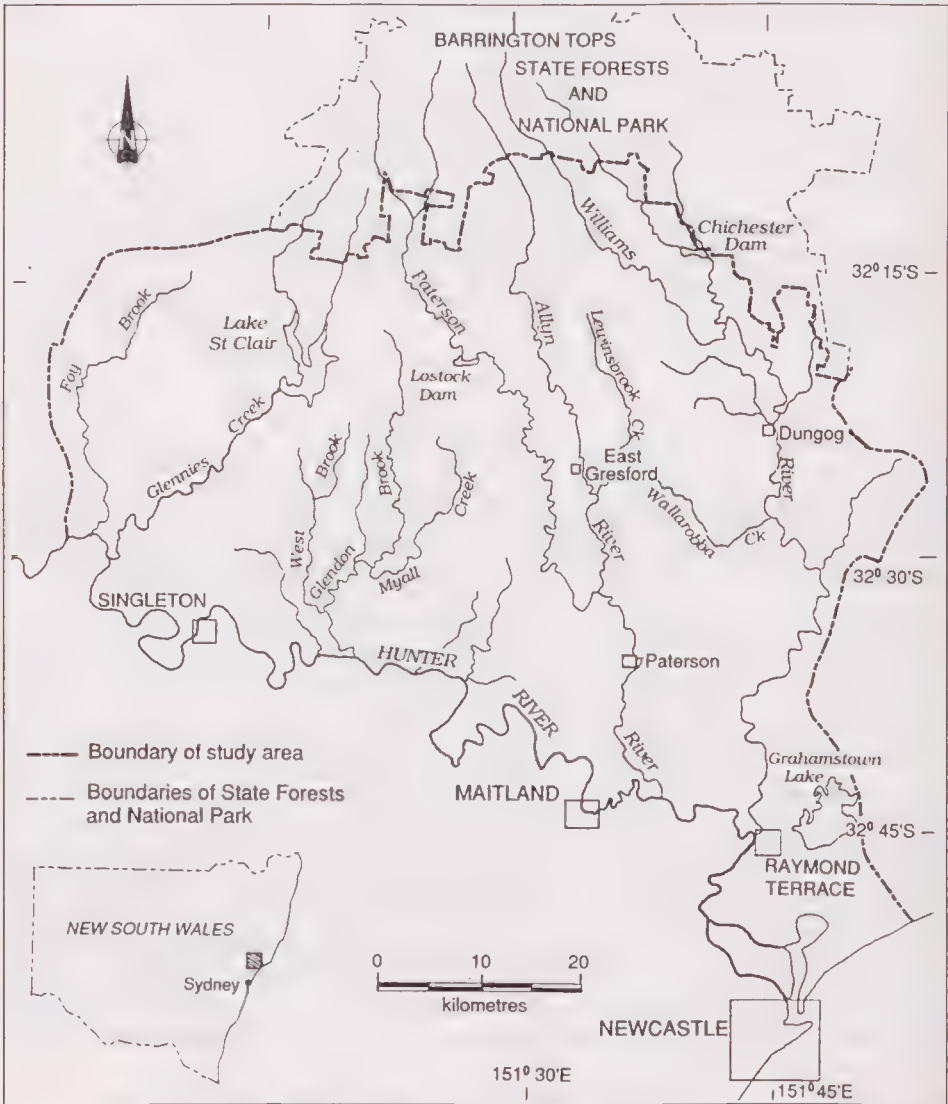


Figure 1. Map of the study area. The southern boundary is the channel of the Hunter River.

(Figure 1). The study area covers about 3 700 km² and includes the small towns of Dungog, Gresford and Paterson. The material in this paper is taken from a more extensive, unpublished report prepared under a National Estate grant (Turner and Vernon 1990).

Physical Setting

Drainage and relief

The major streams of the study area (Williams, Allyn and Paterson Rivers) have their beginnings on or close to the southern scarp of Barrington Tops, and their valleys radiate away from it towards the Hunter River. Even such shorter and lesser streams as Glendon Brook, Glennies Creek and Foy Brook are a part of this radiating pattern (Figure 1). Most of the study area lies below 500 m. In this foothill country, the higher land occurs as ridges between the river valleys. Typically, local relief (the difference in elevation between a main valley floor and the nearest basin divide) is 200 m to 300 m. The floors of the main valleys are generally broad and open.

Rainfall

The isohyet map of Figure 2 has been drawn from annual averages (Bureau of Meteorology data) for some sixty of the stations contained in the atlas assembled by Bridgman (1984). The data are so sparse across the whole area that we have not felt

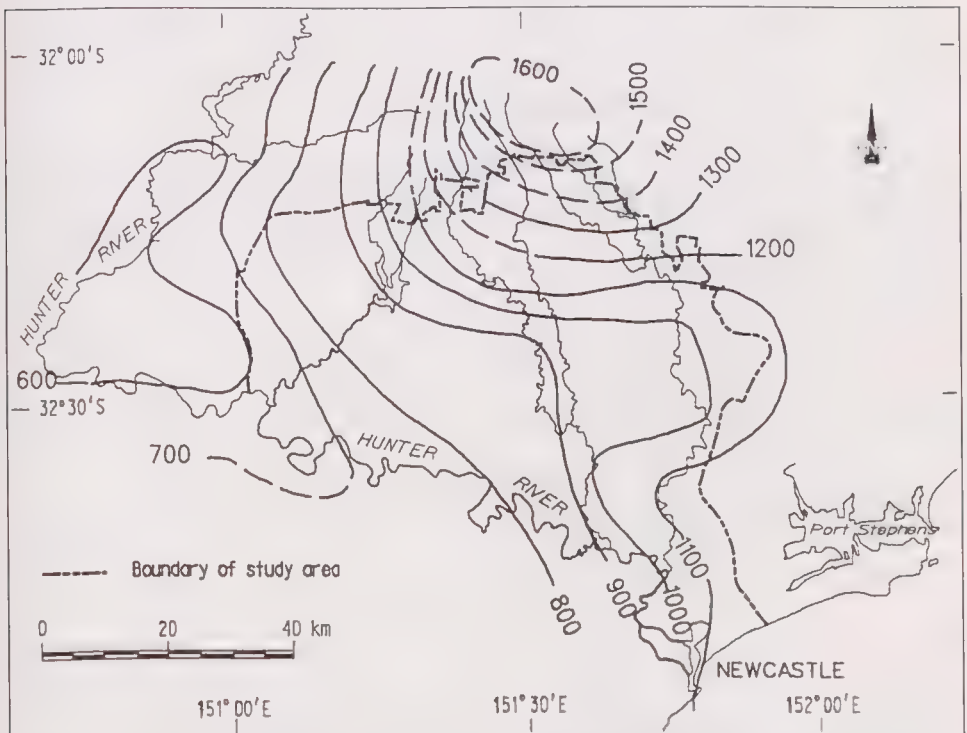


Figure 2. Isohyet map of the study area and vicinity. Smoothed isolines of average annual rainfall in mm.

justified in drawing other than highly-smoothed isolines. Locally, one would expect to find a far from smooth pattern because of aspect and topographic influences. Thus, Figure 2 is only a generalised picture of the annual average rainfall of the area. It probably presents an underestimate of actual rainfall on the higher parts of the foot-hill country on those parts where most of the remaining rainforest stands occur. Regionally, annual rainfall is positively correlated both with closeness to the coastline and with altitude. Across most of the study area the isohyets lie in a south-east to north-west direction.

Geology and soils

Almost all the rocks in the study area are of Devonian and Carboniferous age, many of them very resistant to weathering. Galloway (1963) has given a brief geological description of the Hunter Valley, including the study area.

Both Galloway (1963) and van de Graaff (1963) point out that the soils found on the more resistant rocks are usually skeletal. A small amount of analytical information is available for such soils. One of us (Vernon 1985) has reported on some characteristics of the top 10 cm of the soils she found in four rainforest stands (coded here as C1, C3, W1 and W2). These stands span most of the southerly part of the survey area, in a south-east to north-west sequence. The soils were relatively coarse in texture (ranging from silty loams to loamy sands) and slightly-to-strongly acid. They contained about 10% organic matter and their total phosphorus concentrations were no more than moderate (mean values 0.042% to 0.061%). These four stands occur on acid-to-intermediate vulcanogenic rocks such as rhyodacites, parent materials typical of the range of parent materials underlying the stands examined in detail in this present survey. We expect therefore that the soils of most of the surveyed stands will be very free-draining and of low-to-moderate chemical fertility and water-retaining capacity.

Land systems and landforms

Land systems are 'areas with (their) own characteristic (and recurring) combination of landforms, soils and vegetation' (Story et al.). Stands were assigned to the land systems used in the CSIRO survey of the Hunter Valley (Story et al. 1963), and based on their 1:250 000 land system map sheet. Abbreviated descriptions of the relevant landforms are given below.

Cranky Corner	Extremely steep massive mountains, hills, escarpments [and] deep ravines with rubbly slopes and cliffs, up to [60 m] high.
Mt Butterwicki	• Very steep ridges with narrow crests dissected by closely-spaced ravines giving extremely broken topography; much outcrop; liable to slumping. • Massive hills with extensive cliffs and much surface rubble. • Deep narrow valley heads, generally facing south, bounded by cliffs or very steep slopes; much surface rubble.
Mt Royal	Fairly steep to very steep ridges with broadly rounded summits or narrow crests; slopes dissected by closely-spaced ravines.
Rainforest	• Steep ridges with narrow uneven crests; slopes with closely-spaced deep ravines or with cliffs and bluffs [3–60 m] high. • Basalt screes and cliffs.
Wallaroo	Moderately steep rounded hills [15–100 m] high; lower slopes of major valleys in more rugged areas; broad structural benches and plateaus fringed by cliffs and bluffs up to [15 m] high.

Methods

Air reconnaissance

We decided that systematic low-level aerial reconnaissance, with a colour photographic record, would provide the most effective basis for selecting stands for ground visits. Standard black-and-white stereo aerial photographs were used to supplement the information gained from these light-plane flights where required. Eleven reconnaissance flights were made in Cessna aircraft, covering the whole study area. The flight path was usually 300–500 m above local terrain. At these elevations, a lens of 50 mm focal length on a 35 mm camera gave satisfactory cover of most rainforest stands.

Ground survey

Criteria used in the selection process were size, relative freedom from human-induced disturbance, representative location within the survey area, physical accessibility, and the granting of permission for entry from the land-owner.

We accepted as a working assumption that the larger a stand, the richer in plant species and the more fully developed structurally it was likely to be. In addition, freedom from at least gross disturbance was a self-evident requirement — this was a characteristic which, it was found, could be assessed satisfactorily from direct observation on light-plane flights and from the resulting colour transparencies. Concerning location, we felt that, as well as there being a requirement for breadth of sampling (i.e. across the whole survey area), there was a need for increased intensity of sampling in areas where stands were relatively large and frequent.

Physical difficulty of access prevented visits to a few remote stands, such as some in the upper parts of the valleys of Glendon Brook and the Paterson River (immediately south of State Forest boundaries). In four cases land-owners either refused or showed marked reluctance to allow a visit. As far as possible, nearby stands of similar size were inspected instead. In the event, 42 stands were examined. In addition, some of the data collected by Vernon (1985) for another four stands have been incorporated into our results.

Within each stand an extended route (usually doubling back and forth) was chosen in order to sample as fully as reasonably possible the range of habitats present, having regard to such influences as local topography and aspect. We aimed to complete the inspection of each smaller stand within a day. However, it took two or three days to examine some of the larger stands. For each stand, the presence and relative abundance of individual species were recorded. Four categories of relative abundance were recognised: very common (VC), common (C), occasional (O) and rare (R). These qualitative abundances were assessed by the same person (SV) for every stand but one (Rosewood Gully, C2), with the aim of achieving as much inter-stand consistency as reasonably possible.

The survey area was divided into three sectors, Eastern (E), Central (C) and Western (W), and the surveyed stands in each sector were numbered in sequence from south to north. Thus each stand has been coded by a letter and a number, e.g. C12. The boundaries between sectors were arbitrarily placed along two of the major streams, the Allyn-Paterson River and Glennies Creek (Figure 3). In a few cases (E4, E5, E11, E17, C14), where two or three small stands were close together and could be inspected as a group during one or at most two visits, they have been given a single code designation.

Rock specimens were collected at most stands. Later they were examined and classified by Dr L.N. Morris of the Geology Department, University of Newcastle.

Landscape data

Area

An outline of each stand was drawn on its 1:25 000 topographic map sheet, using for guidance all the available sources of information: black-and-white aerial photographs (with stereo cover), low-level aerial oblique colour transparencies, our ground-survey records, and the pattern of local drainage and contour lines revealed on the map itself. The area of the stand outline was then determined by tracing it on to graph paper and counting the enclosed number of unit squares.

In most cases, the size of the stand had been reduced by past human disturbance. It is now difficult or impossible to estimate where these edges may have stood before settlement. As mapped, however, the stands consist very largely of rainforest still structurally intact. Particularly at the down-stream margins of many stands, there are clear signs of recent and continuing disturbance: broken canopy, lack of normal vertical structure, weed invasion, livestock incursions. Care was taken to try to exclude such areas from the mapped stand outlines.

Eucalypts occur intermingled with rainforest species in many stands — sometimes singly, sometimes in patches, and almost always towards the edges of stands. Mapping is always difficult in such circumstances. Here, we have included single eucalypt trees and very small groups within the stand outline, but have excluded larger groups. The latter commonly occur on ridge lines within the general confines of the larger stands and they are present, for instance, in the Tabbil Creek stand, E10. Very commonly they have a rainforest understorey.

Rainfall

To obtain an estimate of the average annual rainfall of each stand, linear interpolation was applied between the smoothed isohyets shown in Figure 2. No adjustment was attempted for local topographic patterns, although it was recognised that all the stands examined were in upland sites, commonly with southern or eastern exposures, while most of the measuring stations were on the relatively open floors of the major valleys, kilometres or tens of kilometres away.

Altitudes and altitudinal spans

From the outline of each stand drawn on to its 1:25 000 map sheet, the altitudes of the highest and lowest boundaries were read off to the nearest 10 m. The mid-point of these extreme values was then taken as a mean value for the altitude of the stand. The altitudinal span of a stand was taken as the difference between the two extreme values.

Aspect and slope

A subjective assessment of the predominant aspect of each stand was made by inspection of the stand outline drawn on the appropriate 1:25 000 map sheet. The 16-point compass scale was used as the basis of this assessment.

A measure of the overall slope above horizontal of each stand was obtained by measuring, on the 1:25 000 map sheet, the straight-line distance between the highest

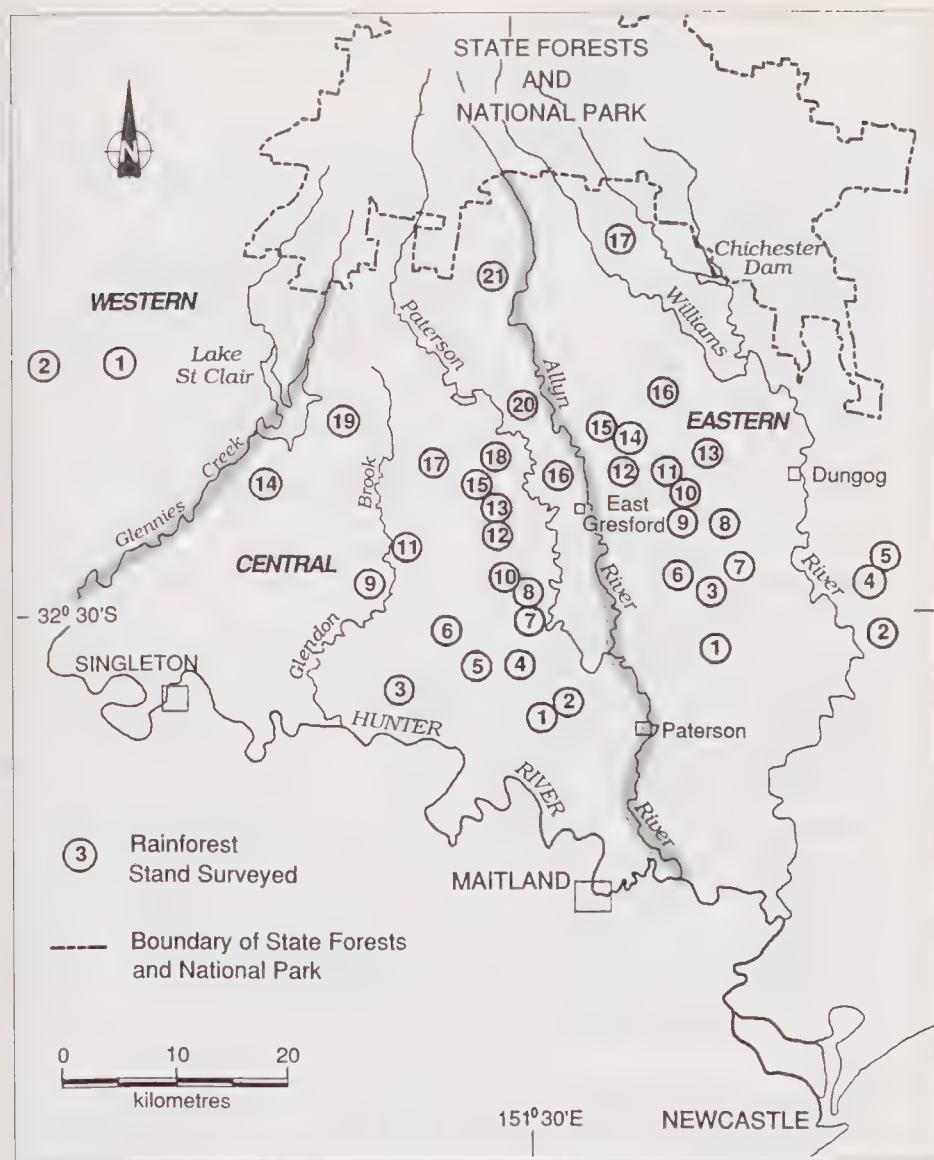


Figure 3. Distribution map of the surveyed stands: Eastern, Central and Western sectors.

and lowest points in the stand (points of known altitude — see earlier) and applying the arctangent relationship to find the angle.

Plant data

Compilation of species lists

Lists of the plants found in the surveyed stands are presented in Appendixes 2 and 3. For some stands occurring very close together, only composite species lists were prepared. Appendix 1 (see further mention in Results) therefore describes more stands than

are apparent in the columns of Appendixes 2 and 3 (see Notes with these two Appendixes). Plant names have been checked against Harden (1990, 1991, 1992) and against Beadle (1971–1987) where appropriate.

The distinction between shrubs and small trees is traditionally made on the basis of both height and form. Specht (1970) for instance defines a shrub as 'a woody plant less than 8 m tall, frequently with many stems arising at or near the base'. In rainforest, however, our observations indicate that most small free-standing woody plants are not multi-stemmed, so it is necessary to draw a dividing line, arbitrarily, on a size criterion alone. We prefer to base the decision on the easily-measured or estimated property of stem circumference at breast height (1.4 m), following the definition: 'a shrub species is a population of woody plants whose members do not consistently attain, at maturity, a stem circumference at breast height greater than 10 cm'. On this criterion, most of the woody plants in question are defined as (small) trees and accordingly our species list for shrubs (Appendixes 2 and 3) is quite short.

We have followed the practice of Floyd (1983a) and have not included eucalypt species in the rainforest species lists. Eucalypts almost invariably occur only near the edges of these dry rainforest stands. *Casuarina cunninghamiana* occurs along some of the larger streams running through stands (e.g. along Webbers Creek in the Moonabung Falls stand, C1). It can be thought of as occupying an internal edge habitat. Two *Melaleuca* species, *M. quinquenervia* and *M. styphelioides*, occur through the stands — the latter species is quite common. In contrast to the eucalypts, these three species have been included on the lists. Eucalypts generally cannot regenerate under a rainforest canopy, so their presence in a stand (perhaps initially due to an incursion by fire) is essentially fortuitous and for a single generation. On the other hand, as far as we know, the *Casuarina* and *Melaleuca* species are stable in their present positions and are able to persist indefinitely.

It is inevitable that some species actually present in an individual stand will not be detected. A species missed in one stand, however, is likely to have been noted in one or more other stands (unless it is of very restricted distribution) — more confidence can be placed on the overall occurrence list than on the presence list for any individual stand. It should be noted too that different weights are necessary when one considers presences compared with absences. A recorded presence is unambiguous but an indicated absence is less clear-cut in its meaning — it may truly be an absence, or it may cover a failure to detect a presence.

We have some data on the effectiveness of sampling of stands. They concern stand C1, Moonabung Falls. In 1982 this stand was surveyed by Floyd (1983a), using very much the same method as we used with other stands: a more-or-less systematic walk through the stand, noting presences. In 1985, detailed plot-work was carried out in the same stand by Vernon, who examined 27 plots each of area 200 m², placed systematically throughout the stand. In Table 1 we compare the results of the two examinations by way of listing the numbers of species detected in the structural groups. Our general expectation is confirmed that a reconnaissance survey tends to yield fewer recorded presences than the results of detailed plot-work across the stand.

Three other stands (Sandy Waterholes, C3; Foy Brook, W1; and Cedar Creek, W2) were also examined in detail by Vernon (1985). As well, another three of the stands surveyed by us had also been surveyed earlier by Floyd (ibid.) in the same way as his examination of Moonabung Falls. For these stands (Mirari Ck, E6; Pilchers Mountain, E8; and Tabbil Ck, E10) the two presence lists have been combined. Thus, the surveyed stands have been subjected to a range of sampling intensities, and the comprehensiveness of their species lists is likely to vary accordingly.

Cluster analysis of the stands

A polythetic agglomerative classification procedure was applied to the stand-by-stand tree species-presence data. In the so-called 'flexible fusion' strategy (described in Williams, 1976), the relative amount of space contraction-dilation allowed in the clustering process is termed the beta value. A small negative beta value has commonly been found to be optimal in obtaining sought-after sharpening of distinctions between nearby clusters. Commonly, a beta value of -0.25 is used. Here, we used SAS Statistics software, procedure CLUSTER (METHOD = FLEXIBLE, beta = -0.25), followed by procedure TREE, which prints a dendrogram as well as the fusion history of the agglomerative steps.

Included in the analysis was the species list termed Wg (Appendix 2), for those rainforest species occurring generally in the Western sector, often as single trees or in very small groups. For present purposes, the Wg list will be termed a 'stand'. The final data matrix contained 44 stands and 85 tree species. A few species were not included because of their low inter-stand frequencies — only one or two occurrences in the 44 stands.

Results

a) The stands in their landscapes

Location

Locational and other information about the stands is presented in Appendix 1. Most of the surveyed stands are concentrated in the stretch of country from Dungog west-south-west towards Singleton. We consider that this pattern mirrors with fair accuracy the density of distribution of stands as a whole, particularly of the larger ones. Stands are small and infrequent in the western part of the survey area. Here, species of undoubted rainforest affinity occur, but in very small groups or, commonly, as isolated individuals. These species, tolerant of relatively dry habitats, will be referred to again later. The scale of their distribution patterns in the west (where the term 'stand' is frequently no longer appropriate to describe their form of occurrence) makes for difficulties in any attempted comparison with stands in the east, which usually are coherent and well-defined, and may be quite large.

Table 1. Comparison of observed species numbers between a reconnaissance survey (Floyd, 1983a) and systematic plot work (Vernon 1985) at Moonabung Falls (stand C1)

Structural group	Numbers of native species		
	from a single reconnaissance visit	from plot work	reconnaissance detailed plot work %
Trees and shrubs	46	67	69
Herbs	8	10	80
Climbers*	17	13	131
Epiphytes and Lithophytes	6	6	100
Overall	77	96	80

* Chalmers and Turner (1994 in press) found 26 species of climbers in this stand. Their expanded list has not been applied to this present report.

Area

The frequency distribution and some statistics of the areas of surveyed stands are set out in Table 2. The frequency distribution is strongly skewed towards larger stands. Mean areas were also calculated separately for the 20 stands in the eastern sector and for the 26 stands in the central and western sectors. As expected, the mean size of the eastern-sector stands (22.6 ha) is markedly higher than that for the stands of the other two sectors (15.8 ha).

Rainfall

For the 46 rainforest stands examined, estimated average annual rainfall values range from 750 mm to 1 400 mm, with most stands in the 800–1 000 mm range (Table 3).

Topographic types and land systems

Our observations suggested that the topographic situations in which stands occurred could be assigned to the following general types.

Down-stream valley site

A down-stream valley stand occurs in a side valley usually well removed (typically kilometers) from the extreme headwater tract of its tributary valley. The presence of the stand is associated with a local topographic feature providing sheltered habitats, perhaps a gorge, e.g. stand C1 below Moonibung Falls.

Gully-head amphitheatre

In some cases there are amphitheatre-like hollows at the extreme heads of streams. These hollows, usually with very uneven and scree-covered floors, provide sheltered

Table 2. Frequency distribution and statistics of the areas of surveyed stands

	Area class (ha)					
	0–9	10–19	20–29	30–39	40–49	≥50
Number of stands (Total = 46)	15	16	8	3	1	3
Mean	= 18.7 ha		Median	= 15.5 ha		
Standard deviation	= ± 17.0 ha		Range	= 1.5–84 ha		

Table 3. Frequency distribution and statistics of the estimated average annual rainfall of surveyed stands

Rainfall class (mm/year)								
	700– 799	800– 899	900– 999	1000– 1099	1100– 1199	1200– 1299	1300– 1399	1400– 1499
Number of stands (Total = 46)	2	17	15	9	1	1	0	1
Mean	= 930 mm			Median	= 900 mm			
Standard deviation	= ± 110 mm			Range	= 750–1400 mm			
Mean of eastern-sector stands = 1005 mm				Mean of central- and western- sector stands = 880 mm				

habitats and often contain rainforest stands. An example is the Pilchers Mountain stand, E8.

Single and multiple gully-heads

At the extreme heads of streams ('gullies' at that stage) rainforest stands often occur. Depending on the local pattern of drainage and topography, a stand may be relatively small and occupy a single gully head, which may have minor tributaries within the stand (e.g. Bingleburra, stand E12), or it may connect across several neighbouring gullies (e.g. Wallarobba Range: NE section, stand E13). In both cases, the stand is often roughly triangular in overall outline, with apex down-slope where a consolidated stream finally emerges.

Weakly-gullied rocky slopes

Some stands occur on very rocky slopes where drainage lines and channels are not strongly developed. In these cases, the stand may be largely underlain by scree and there may be low cliffs immediately above (e.g. the Lees Mountain stand, C7). The presence of rainforest plants may be encouraged on some substrates of fragmented rock because relatively more of the infiltrated rain water is likely to be available to plants than in non-rocky soils. There may also be additional water from run-off from cliffs.

A combined frequency table has been drawn up for all surveyed stands in terms of the land systems and topographic types to which they can be assigned (Table 4). Stands occur on five land systems — they are particularly common on Cranky Corner and Mt Butterwicki, both of which are notable for rugged landscapes. As regards the five defined topographic types, gully heads, both single and multiple, are by far the most common sites for the occurrence of the surveyed stands.

Altitudes and altitudinal spans

The frequency distributions and some statistics of the altitudes and altitudinal spans of the surveyed stands are set out in Tables 5 and 6 respectively. These two frequency distributions, unlike those for stand area and average annual rainfall, are more or less symmetrical in shape, with the modal class centrally placed.

Table 4. Frequency distributions of stands with respect to land systems and topographic types

		Land System					Total
		Cranky Corner	Mt Butter- wicki	Mt Royal	Rain- forest	Wallaroo	
Topographic type	Down-stream valley site	5	4				9
	Gully-head amphitheatre		4			3	7
	Multiple gully-heads	4	8	1	1		14
	Single gully-heads	5	5			2	13
	Weakly-gullied rocky slopes	1	1			2	4
	Total	15	22	1	1	7	46

Aspect and slope

A combined frequency table for aspect and slope of all surveyed stands is presented in Table 7, together with some relevant statistics. The reader will appreciate the gross approximation involved in the selection of a single direction to represent the diverse array of aspects encompassed in a stand, particularly a large one. Most of the stands have predominant aspects lying from E through SE to SSW.

Lithological background

The rock specimens collected were all of Carboniferous age. They were derived almost entirely from volcanic activity, being either lavas of an acid or intermediate type, or sedimentary rocks (mostly fine-grained tuffs) derived from similar igneous rocks. In these latter cases, the sedimentation seems generally to have occurred in terrestrial environments (L.N. Morris, pers. comm.).

From these findings, it cannot be expected that the fertility of the associated soils will be any higher than low-to-moderate. It seems likely that the surface-soil analytical results for four of the stands (C1, C3, W1, W2; Vernon, 1985) mentioned earlier will be of broad applicability across the surveyed stands. The presence of some oolites at two of the stands (E2 and E9) suggests that at least some of the soils under these particular stands will be enriched in calcium.

Only one rock specimen was collected from most of the stands. Inevitably some stands, particularly the larger ones, will possess a lithological heterogeneity not revealed in our results. However, even if the sampling had been exhaustive, there would be no reason to expect conclusions about general soil fertility levels different from those set out above.

The modal stand

A number of physical features of the surveyed stands have been described. In Table 8 we summarise the modal characteristics of stands. For those characteristics where a numerical scale is employed, the specific bounds of the modal classes shown in the

Table 5. Frequency distribution and statistics of the mid-point altitudes of the surveyed stands

	Altitude class (m)			
	1-99	100-199	200-299	300-399
Number of stands (Total = 46)	3	9	22	12
Mean = 242 m	Median = 245 m			
Standard deviation = ± 77 m	Range = 90-380 m			

Table 6. Frequency distribution and statistics of the altitudinal span of the surveyed stands

	Altitude-span class (m)					
	50-99	100-149	150-199	200-249	250-299	300-349
Number of stands (Total = 46)	7	10	16	8	4	1
Mean = 163 m	Median = 160 m					
Standard deviation = ± 64 m	Range = 50-310 m					

table have been arbitrarily chosen — no great significance or exactitude should be read into the selected limits. The means and medians lie within the respective modal classes, or close to them.

Results

b) The rainforest vegetation

Rainforest structural types

The surveyed stands are examples of dry rainforest. Williams et al. (1984) provide a description of this rainforest type, which they recognise as one of the four sub-formations of rainforest occurring in NSW. Characteristics important in distinguishing dry rainforest from the other sub-formations are listed below in Table 9.

There is no single structural or floristic feature which uniquely distinguishes dry rainforest from the other sub-formations. Each sub-formation grades continuously into one or more of the others. Dry rainforest, for instance, may grade into sub-tropical rainforest along a moisture-supply gradient (in circumstances where temperature is more-or-less constant) or into warm-temperate rainforest along combined moisture and temperature gradients (increasing moisture and decreasing temperature). The sense of continuity between the sub-formations is reinforced by the fact that some species show a very wide environmental tolerance, occurring in three or even in all four sub-formations.

Table 7. Frequency distributions and statistics of stands with respect to predominant aspect and overall slope inclination

Predominant aspect	Slope-inclination class (°)				Totals
	5-9	10-14	15-19	20-24	
N		1	1	2	
NNE		1		1	
NE	1			1	2
ENE		1			1
E	1	2	2		5
ESE		1	1	1	3
SE	3	5	4	1	13
SSE		2	1		3
S	4	1	3	1	9
SSW	2	1	1		4
SW			1		1
WSW			1		1
W					0
WNW		1			1
NW		1		1	
NNW					0
Totals	11	17	14	4	46

SLOPE INCLINATION

Mean	= 13.2°	Median	= 13°
Standard deviation	= ± 4.6°	Range	= 5°-24°

ASPECT

Mode	= south-east	Median	= south-east
------	--------------	--------	--------------

Vernon (1985) assessed the four stands which she was studying in terms of the classification system of Webb (1978). She concluded that they could be regarded as examples both of dry rainforest and of simple notophyll low vine forest (Webb terminology), and we think that these terms can be applied to all the stands in the present survey. Even stand E17, Chichester Gap, which is close to the southern scarp of Barrington Tops and is relatively high (mid-point 375 m in altitude) and wet (1 400 mm estimated average annual rainfall), still fits most of the characteristics for dry rainforest (Table 9). All of these stands, however, possess some characteristics linking them to the sub-tropical and/or warm temperate rainforest sub-formations. This is especially so with those (larger) stands occupying a wide range of topographically-determined habitats. Here, in the most sheltered habitats, for instance, the forest may approach, locally, sub-tropical rainforest in its structure and floristics. Later we examine further the notion of the mixed nature of the surveyed stands.

Species frequencies and abundances

Inter-stand frequencies

The inter-stand frequency of a species is defined here as the percentage of all those stands under study in which the species was observed. It provides a measure of the relative degree of spread of a species across the surveyed stands, and gives no indication at all of the intra-stand abundances of that species. The term *frequency* in plant ecology normally applies to the percentage presence of a species across a number of plots, all of the same size. Our surveyed stands (by analogy, to be thought of as 'plots') range widely in area, so there can only be a broad qualitative similarity between these two frequency terms. To provide an indication of variation in inter-stand frequencies *within* the surveyed area, values have also been calculated separately for the eastern-sector stands and for the central- and western-sector stands combined. Table 10 summarises some of the variability in inter-stand frequency. Species have been included in the Table if their inter-stand frequencies in E and in C + W stands differ by twenty or more percentage points. This figure is an arbitrary choice — it is meant to signify a marked difference unlikely to be due to chance alone.

More species show a large inter-stand frequency decline in the east-to-west direction than show such a decline in the opposite direction. This trend is particularly strong for vines and epiphytes/lithophytes. This supports the expectation that many rainforest species will become less frequent as the distance from the coast increases, mainly for reasons of diminished moisture supply, but also connected with reduced

Table 8. The modal stand amongst the forty-six surveyed

Characteristic	Modal class
Area	10–19 ha
Average annual rainfall	800–899 mm
Land system	Mt Butterwicki
Topographic type	Multiple gully heads
Altitude	200–299 m
Altitudinal span	150–199 m
Predominant aspect	South-east
Overall slope inclination	10–14°
Underlying rock type	Fine-grained tuffs derived from acid volcanics
Geological age	Carboniferous

Table 9. Prime distinguishing features of dry rainforest (after Williams et al., 1984)**Trees**

- A more-or-less continuous canopy stratum, above it a discontinuous stratum ('emergents').
- A discontinuous small-tree stratum.
- A rich array of species.
- Leaf-sized, small, mainly microphyll.

Climbers

- Large woody climbers are common and diverse.

Epiphytes

- Large epiphytes may be either rare or common, but there are few species.

Special features

- Mosses and ground ferns rare, no tree-ferns, prickly shrubs common.

Habitat

- Warm areas with fairly low average annual rainfall (600–1100 mm).

Floristics

- A small number of emergent species occur; they include the lace-bark tree, *Brachychiton discolor*.
- The canopy and small-tree strata are often dominated by species of a few families, particularly (in the Hunter Valley) Euphorbiaceae and Sapindaceae.

chances of arrival and establishment of disseminules at individual stands (the past supply of disseminules being assumed to be at a maximum close to the coast at a time-scale of centuries, millenia and longer).

Abundances and inter-stand frequencies considered together

Centrally important features of forest vegetation are the floristic composition of the tree strata and the relative abundances of the species, especially in the main canopy layer. In Table 11 attention is concentrated on those tree species assessed as abundant (VC or C) in most of the stands. The twelve most successful species in this sense are arranged in the Table in decreasing order of inter-stand frequency. Some of these trees do not normally reach the canopy stratum of the forest. Information from Floyd (1989) on tree heights is presented in the right hand column of the Table. In the Hunter Valley, *Cleistanthus cunninghamii*, *Croton verreauxii*, and *Claoxylon australe* are not tall enough to be counted as members of the canopy stratum. The eight other species in the list can be included as well, although some of them, such as *Streblus brunonianus* and *Elattostachys nervosa*, often reach only the lower part of the canopy. In terms of its consistently high abundance, *Streblus* is clearly in a class by itself. Further down the list, there are large gaps in inter-stand frequency (in the VC + C column) below *Capparis arborea* and below *Croton verreauxii*.

The three species most often noted as emergents in the stands examined are also listed in Table 11: *Brachychiton discolor*, *Ficus macrophylla* and *F. superba* var. *hemneana*. It is a characteristic of the emergents that they are rarely present in large numbers in a stand — examination of Table 11 shows that their (O + R) inter-stand frequencies are much greater than their (VC + C) inter-stand frequencies.

Table 10. List of those species showing large ($\geq 20\%$) inter-stand frequency differences between E and C + W sectors**E >> (C + W)****Trees (total spp = 95)**

Alangium villosum
Actephila lindleyi
Citronella moorei
Pennantia cunninghamii
Backhousia sciadophora
Melicope micrococca
Elattostachys nervosa
Celtis paniculata
Dendrocnide photinophylla
 (n = 9)

Shrubs (total spp = 17)

Pittosporum revolutum
Spartothamnella juncea
 **Lantana camara*
 (n = 3)

Herbs (total spp = 25)

Alocasia macrorrhizos
Gymnostachys anceps
Lastreopsis microsora
Polia crispata
 (n = 4)

Climbers (total spp = 40)

Parsonia velutina
Gymnema pleiadenium
 **Delairea odorata*
Pandorea pandorana
Dioscorea transversa
Austrosteenisia blackii
Stephania japonica
 **Passiflora subpeltata*
Piper novae-hollandiae
Morinda acutifolia
 (n = 10)

Epiphytes/lithophytes (total spp = 23)

Asplenium attenuatum
Asplenium australasicum
Dendrobium speciosum
Dendrobium teretifolium
Peperomia leptostachya
Platynerium sperbum
 (n = 6)

(C + W) >> E

Scolopia braunii
Toona australis
Austromyrtus acmenoides
Backhousia myrtifolia
Pittosporum undulatum
Podocarpus elatus
Sarcomelicope simplicifolia

(n = 7)

Pseuderanthemum variabile
Plectranthus parviflorus
Viola hederacea

(n = 3)

Passiflora herbertiana

(n = 1)

(n = 0)

Notes. Eastern sector (E) : 18 stands; Central (C) and Western (W) sectors : 25 stands. (A total of 43 stands; reduced from the 46 stands of Appendix 1 because of some consolidation of species lists — see notes accompanying Appendixes 2 and 3.) - Within each structural category, the genera are arranged in the same (family-ordered) sequence as that in which they occur in Appendixes 2 and 3. - * denotes a naturalised species.

Attention has been given so far to those tree species which are both most frequent across stands and most abundant within stands. The situation in the other structural groups must now be briefly examined. Table 12 lists in decreasing order, in the same way as Table 11, those species with the highest inter-stand frequencies in each group. The results provide agreement with that part of the description of dry rainforest set out in Table 9 concerning the general sparseness of Herb (mostly ferns) and

Table 11. Most frequent and abundant tree species

Species	Inter-stand frequencies (%) in the following intra-stand abundance categories:*			Tree height (m) (Floyd 1989)
	VC+C	O+R	Total	
Trees with the highest VC + C frequencies				
<i>Streblus brunonianus</i>	98	2	100	30
<i>Mallotus philippensis</i>	84	14	98	25
<i>Capparis arborea</i>	81	19	100	10
<i>Baloghia inophylla</i>	65	35	100	25
<i>Olea paniculata</i>	60	28	100	30
<i>Dendrocnide excelsa</i>	58	35	93	40
<i>Cleistanthus cunninghamii</i>	53	28	81	9
<i>Drypetes australasica</i>	53	21	74	25
<i>Croton verreauxii</i>	49	51	100	20
<i>Elattostachys nervosa</i>	33	51	84	30
<i>Claoxylon australe</i>	32	63	95	9
<i>Geijera salicifolia</i> var. <i>latifolia</i>	26	67	93	30
Trees often present as emergents				
<i>Brachychiton discolor</i>	11	77	88	30
<i>Ficus macrophylla</i>	2	56	58	50
<i>Ficus superba</i> var. <i>henneana</i>	0	65	65	35

* Abundance information drawn from the full range of data (43 stands) set out in Appendixes 2 and 3.
VC : Very common, C : Common, O : Occasional, R : Rare, very infrequent

Epiphyte/Lithophyte groups. Here too the same comment can be applied to the Shrub group. In all three groups, for almost all the small number of species involved, there are few stands where abundances are high. In contrast, the success of the Climber group is apparent, particularly large woody climbers. All of the eight listed climbers are woody and of them only *Legnephora moorei* does not attain large stem diameters.

So far those species have been emphasised which are both frequent and abundant. Obviously, other categories could also be considered. We shall look briefly at only one group: tree species of high inter-stand frequency but of consistently low abundance. Table 13 is organised in a way similar to Table 11 — it lists, in decreasing order, the 16 tree species with the highest inter-stand frequencies of O and R abundances.

This information serves to point up the richness of the tree flora in the dry rainforest of the Hunter Valley. These sixteen species take us down to a frequency of 70%, still relatively high — there are many other species as well with lower frequencies. The listed species range from tall trees down almost to shrubs — as a group, they are most important in helping to fill the top three strata of the forest with populations successful in terms of their spread amongst stands but rarely large locally.

To emphasise the point that some tree species seem never to be abundant in individual stands, Table 13 lists separately (with some repetition from the main part of the Table) those six species having, at the same time, the highest O and R frequencies and zero frequencies in the VC + C abundance categories.

Table 12. Shrub, herb, climber and epiphyte/lithophyte species with the highest inter-stand frequencies and high intra-stand abundances

Species	Inter-stand frequencies (%) in the following intra-stand abundance categories:*		
	VC + C	O + R	Total
Shrubs with the highest VC + C frequencies			
<i>Citriobatus pauciflorus</i>	97	0	97
<i>Lantana camara</i> **	63	14	77
<i>Abutilon oxycarpum</i>	14	58	72
Herbs with the highest VC + C frequencies			
<i>Adiantum formosum</i>	56	37	93
<i>Pellaea falcata</i> var. <i>falcata</i>	42	56	98
<i>Doodia aspera</i>	38	57	95
<i>Adiantum aethiopicum</i>	29	67	96
<i>Pellaea falcata</i> var. <i>nana</i>	19	71	90
Climbers with the highest VC + C frequencies			
<i>Cissus antarctica</i>	98	2	100
<i>Parsonsia straminea</i>	77	23	100
<i>Tetrastigma nitens</i>	77	23	100
<i>Austrosteenisia blackii</i>	56	12	68
<i>Legnephora moorei</i>	47	47	94
<i>Pandorea pandorana</i>	35	65	100
<i>Malaisia scandens</i>	30	56	86
<i>Jasminum volubile</i>	30	42	72
Epiphytes and Lithophytes with the highest VC + C frequencies			
<i>Pyrrosia confluens</i>	38	60	98
<i>Dendrobium speciosum</i>	7	64	71
<i>Asplenium australasicum</i>	5	40	45

* Abundance information as for Table 11.

** An introduced species, now naturalised.

Species numbers in individual stands

Table 14 presents total observed species numbers as well as statistics of numbers of species per stand for each of the structural groups. Some comparable data from other Hunter Region rainforest studies are also included. The figures serve to emphasise once again the richness of these dry rainforest stands in woody plants, especially trees and vines, in agreement with the broad description given in Table 9. The stands of warm-temperate rainforest studied by Gambrill (1986) occur on the south-western margin of the Hunter Valley and are notably poor in species.

Within a particular region, what measures might be used to predict the floristic richness of individual stands? It is reasonable to expect that stand area (as a crude measure of relative habitat diversity) will be positively associated with species numbers. Another stand characteristic which might also be expected to be directly related to habitat diversity is altitudinal span. Assuming that the coastal belt of the

Table 13. Tree species with high inter-stand frequencies and low intra-stand abundances

Species	Inter-stand frequencies (%) in the following intra-stand abundance categories:*			Tree height (m) (Floyd, 1989)
	O+R	VC+C	Total	
Trees with the highest O + R frequencies				
<i>Hibiscus heterophyllus</i>	91	9	100	6
<i>Notelaea longifolia</i>	91	7	97	9
<i>Clerodendrum tomentosum</i>	88	2	91	15
<i>Cassine australis</i>	86	9	95	8-9
<i>Scolopia braunii</i>	81	0	81	25
<i>Alphitonia excelsa</i>	79	5	84	35
<i>Alectryon subcinereus</i>	79	14	93	18
<i>Elaeocarpus obovatus</i>	77	9	86	45
<i>Toona ciliata</i>	74	5	79	45
<i>Pararchidendron pruinosum</i>	74	0	74	15
<i>Diploglottis australis</i>	74	12	86	35
<i>Ficus rubiginosa</i>	72	5	77	30
<i>Diospyros australis</i>	70	16	88	20
<i>Dysoxylum fraserianum</i>	70	16	86	55
<i>Hymenosporum flavum</i>	70	2	72	20
<i>Melicope micrococca</i>	70	0	70	35
Trees with the highest O + R frequencies and with zero VC + C frequencies				
<i>Scolopia braunii</i>	81	0	81	25
<i>Pararchidendron pruinosum</i>	74	0	74	15
<i>Melicope micrococca</i>	70	0	70	25
<i>Guioa semiglauc</i>	67	0	67	18
<i>Polyscias elegans</i>	67	0	67	30
<i>Wilkiea heuqueliana</i>	58	0	58	8

* Abundance information as for Table 11.

VC : Very common, C : Common, O : Occasional, R : Rare, very infrequent

Hunter Valley has been the main local source of lowland rainforest species over long periods (kept supplied by northward and southward migrations along the east coast of the continent), then the distance of a stand from the coast may be an inverse measure of the relative accessibility of that stand to disseminules. Present average annual rainfall is an environmental variable which may have both direct (moisture supply to individual plants) and indirect (an influence on stand size and hence on habitat diversity) effects.

These considerations provide no more than a very rough basis for a search for possible associations between species numbers and landscape variables of various kinds. The complexity of the situation derives in part from unknown but continuing influences of climatic regimes of the past. Product-moment correlation coefficients have been calculated in turn between species numbers per stand in the various structural groups and the variables mentioned above. Another variable has also been incorporated: the overall slope angle of individual stands (Table 15).

Three or more correlation coefficients designated as significantly different from zero occur for each of the stand characteristics, area, slope angle and altitudinal span

Table 14. Species* numbers in the surveyed stands of dry rainforest and other rain-forest types in the Hunter region

	Structural Group					Total
	Trees	Shrubs	Herbs	Climbers	Epiphytes/ Lithophytes	
The present survey						
Total spp numbers across all surveyed stands	95	13	25	37	23	193
Total spp numbers in the Eastern stands	88	11	24	37	20	180
Total spp numbers in the Central and Western stands combined	88	12	25	33	18	176
Range	32–71	3–9	6–20	9–32	1–16	64–144
Median	45	5	12.5	19	6	88
Mean	47.4	5.4	12.2	18.9	6.4	90.6
Standard deviation (±)	8.7	1.5	3.3	4.3	3.4	17.6
Coefficient variation (%)	18	28	27	23	53	19
Numbers of stands included	43	43	42	43	42	42
Other local studies						
Total spp numbers across all surveyed stands:						
• Liverpool Ra: warm-temperate rainforest (Fisher 1980)	35	16	26	20	12	109
• Wollemi basalt caps: warm-temperate rainforest (Gambrill 1986)	9	7	ND	6	ND	ND

* Only native species (but not eucalypts, grasses or sedges) included.
ND : Not determined

against species numbers. The strongest and most numerous of these associations occur in the case of stand area: all the plant structural groups except herbs are involved. The association between species numbers and slope angle is not as strong and is negative: the steeper a stand, the fewer species it tends to have, especially trees. The association between species numbers and altitudinal span is a positive one but it occurs only with the subsidiary structural groups, not trees. Contrary to our expectation, distance from the coast has no pronounced association with species numbers, and for average annual rainfall there is only one significant association (with climbers).

The basic assumptions of normality of variate distribution and randomness of sample selection should apply to the data on which Table 15 is based just as in any other

Table 15. Product-moment correlation coefficients between species numbers in stands of dry rainforest and some physical characteristics of stands

Stand Characteristics	Structural Group (Species numbers per stand)							
	Trees	Shrubs	Herbs	Climbers	Epiphytes/ Lithophytes	Trees+ shrubs	Trees+ shrubs+ vines	Total
Altitudinal span	0.111	0.367*	0.365*	0.331*	0.222	0.167	0.240	0.268
Area	0.500**	0.298*	0.295	0.390**	0.595**	0.522**	0.525**	0.537**
Average annual rainfall	0.012	0.013	0.258	0.358*	0.190	0.013	0.135	0.176
Distance from coastline	-0.086	0.135	0.030	-0.225	-0.275	-0.058	-0.122	-0.145
Slope angle	-0.399**	0.074	-0.366*	-0.185	-0.338*	-0.365*	-0.337*	-0.380*
Sample size	43	43	42	43	42	43	43	42

* Correlation coefficient significantly different from 0, $p \leq 0.05$. ** Correlation coefficient significantly different from 0, $p \leq 0.01$.

significance testing of a parametric type. In fact, however, both assumptions must be regarded as being no more than roughly fulfilled in the present case (a common feature of field ecological analysis), and interpretation of results should accordingly be very conservative. The reader will recall also that the data themselves have some uncertainties: it was pointed out earlier that the species numbers are very likely to be under-estimates, and under-estimates in varying degrees, of the true values (see Table 1). The stand measures employed are probably no better than crude surrogates for the critical (but unknown-in-detail) environmental and historical controls.

Two of the stands, Mirari Creek (C6) and Pilchers Mountain (C8), are particularly rich in species. The species lists for both stands (Appendix 2) are composites of visits by Floyd (1983a) and by Vernon in this present survey. However, we are of the opinion that, despite this double sampling, the observed richness is real compared with other stands. Both of them lie on the Wallarobba Range, near the eastern side of the survey area, and each seems to have a considerable amount of internal heterogeneity of topography. However, neither is unique in this respect and we are unable to offer a convincing explanation of their extreme richness.

Distribution patterns of individual species

Species at their southern limits

Eleven rainforest species — five trees, one herb and five climbers — are considered to be at their southern limits within the survey area (Table 16). Our survey has changed only slightly, and then not for all of the listed species, the limits established by Floyd (1983a, 1989). The new limits should be regarded as no more than provisional — continuing reconnaissance frequently leads to expansion of the known ranges of plants.

The latitudinal span of the known southern limits of these eleven species is about 16.5 minutes or 30.5 km, extending from Tabbil Ck (Stand E10, at 32° 24.7' S) to Comerfords Hill (at 32° 41.2' S — centre of stand: grid reference 654 825, Maitland 1:25 000 map sheet).

The distributions of selected species across the surveyed stands

It is feasible here to plot the observed distribution of only a small number of the species encountered in the survey. The distribution patterns of the three emergents having the highest inter-stand frequencies (*Brachychiton discolor*, *Ficus macrophylla* and *F. superba* var. *henneana*) are presented in Figure 4. Within the survey area, *Brachychiton discolor* is at its known southern limit. Included in Figure 5 is another southern-limit species, *Backhousia sciadophora*. Figure 5 also shows the patterns of occurrence of a further two trees of restricted local distribution (*Canthium copmosmoides* and *Podocarpus elatus*) and also of the locally-widespread weed, *Lantana camara*.

The three emergents mapped in Figure 4 are fairly consistently absent from the peripheral stands of those examined in the survey area. In two stands, E17 on the northern side and C2 on the southern side, none of the emergents was seen, and in other peripheral stands, only one of the three species was noted. We consider that the presence of emergents is an indication of dry rainforest in the Hunter Valley in its most mature and complex form. Those peripheral stands without emergents usually

Table 16. Species with known southern limits in the dry rainforest stands of the survey area

Species	Southern limits previously observed	New limit
Trees		
<i>Backhousia sciadophora</i>	Mirari Ck, Mt Ararat (E6) (Floyd 1989)	Mt Douglas (E1)
<i>Brachychiton discolor</i> *	Paterson (probably Moonabung Falls) (Floyd 1989)	Kilfoyles Ck
<i>Cleistanthus cunninghamii</i> *	Moonabung Falls (C1) (Floyd 1989)	Comerfords Hill
<i>Dysoxylum rufum</i>	Bulahdelah and Williams R (Floyd 1989)	Tabbil Ck (E10)
<i>Elaeostachys nervosa</i>	Paterson (probably Moonabung Falls) (Floyd 1989)	Moonabung Falls (C1)
Herbs		
<i>Tripeladenia cunninghamii</i> (= <i>Kreysigia multiflora</i>)	Bulahdelah (Rotherham et al. 1975)	Rosewood Gully (C2)
Climbers		
<i>Cayratia eurycnema</i>	Pilchers Mountain (E8) (Floyd 1983a)	(Not observed in present survey)
<i>Gymnema pleiadenium</i> *	Pilchers Mountain (E8) (Floyd, 1983a)	Moonabung Falls (Chalmers & Turner, 1994)
<i>Marsdenia suberosa</i> *	Mirari Ck, Mt. Ararat (E6) (Floyd 1983a)	Comerfords Hill
<i>Morinda acutifolia</i>	Moonabung Falls (C1) (Floyd 1983a)	Moonabung Falls (C1)
<i>Parsonsia velutina</i>	Moonabung Falls (C1) (Floyd 1983a)	Moonabung Falls (C1)

* Limits determined since the survey was completed. The Kilfoyles Ck stand is 4 km south-west of Moonabung Falls. Comerfords Hill is a bluff on the northern bank of the Hunter River, about 11 km south-south-east of Moonabung Falls.

possess other characteristics of dry rainforest, of course, such as an abundance of woody climbers of certain species and an array of many of the typical tree species. It is of interest that even the two most westerly stands, W1 and W2, are not without one of the three emergents referred to in Figure 4, *Ficus superba* var. *henneana* in this case.

Two tree species showing marked tendencies to east-west localised distributions are *Podocarpus elatus* and *Backhousia sciadophora* (Figure 5). *Podocarpus elatus* was observed only in the Central sector and *B. sciadophora* only in the Eastern sector, mainly on the

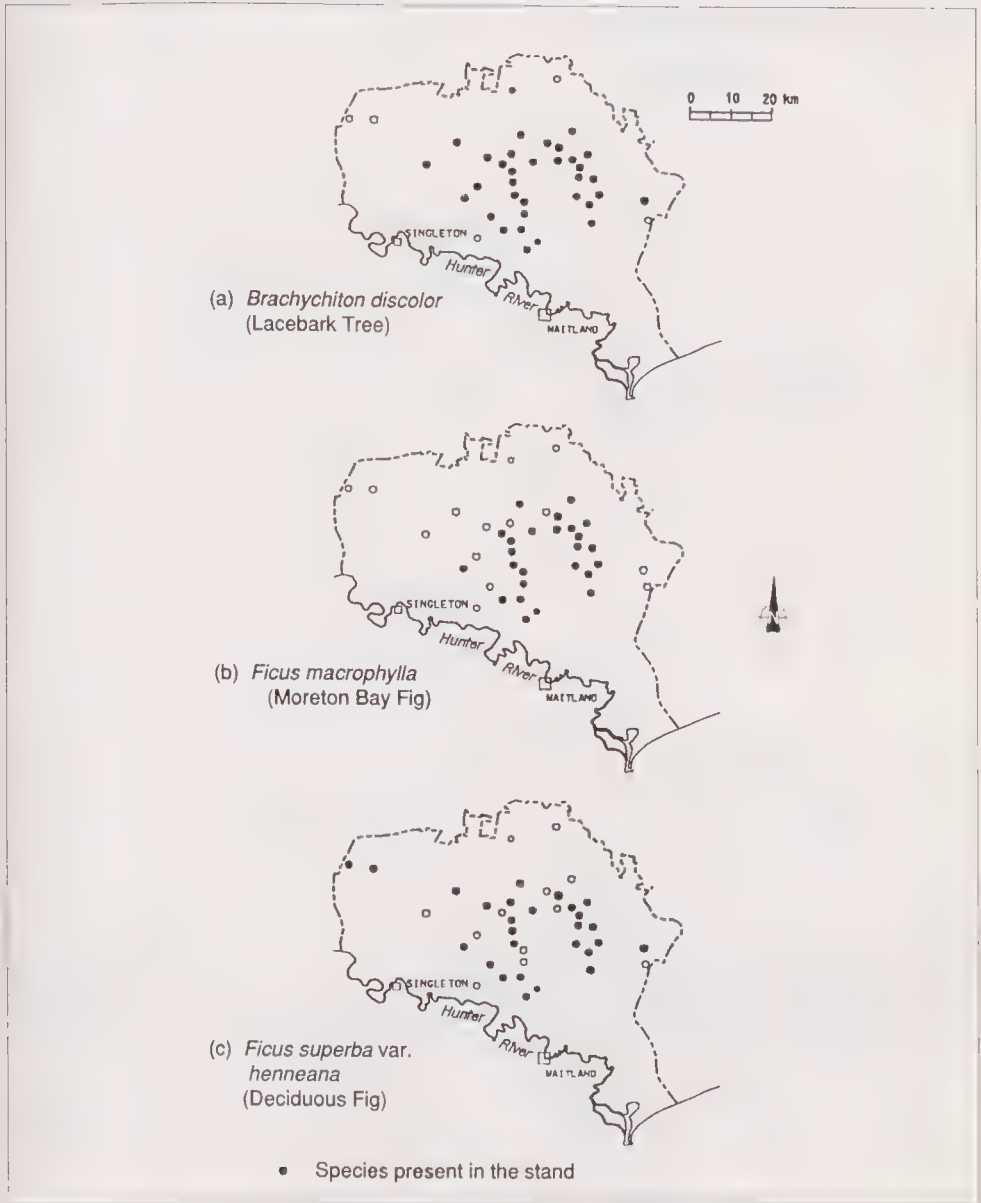


Figure 4. Maps of the observed occurrence of three emergent tree species amongst the surveyed stands. Because of the scale used, it has been judged necessary to merge some closely contiguous stands.

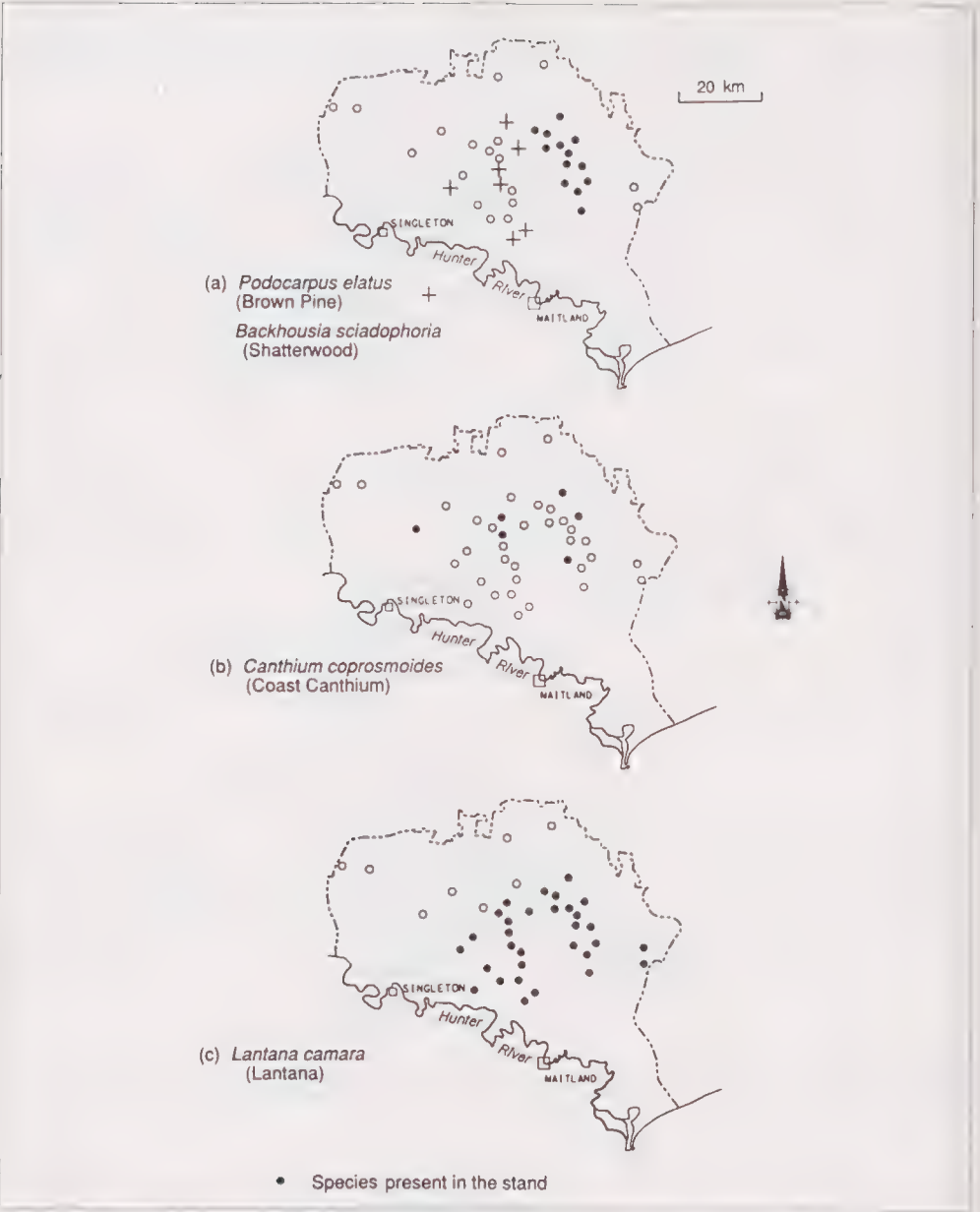


Figure 5. Maps of the observed occurrence of three tree species and the shrub/scrambler, *Lantana camara*, amongst the surveyed stands. Because of the scale used, some closely contiguous stands have been merged.

Wallarobba Range. In contrast, *Canthium coprosmoides* occurs in both Eastern and Central sectors, seemingly becoming more restricted in its distribution towards the west. The westernmost stand in which it was seen, C18, is 63 km from the nearest coast, unexpectedly far given the tree's common name of Coast Canthium and its usually-recorded distribution (Floyd 1989) in near-coastal sites.

The weed *Lantana camara* is widespread as well as abundant in Eastern and Central stands (Figure 5), but clearly there are limitations to its occurrence to the north and west. To the north (stands E17 and C21), low temperatures are most likely limiting,

to the west moisture supply is probably critical. There is a possibility too that the species has not yet fully occupied its potential range here and that it may still be moving, albeit slowly, to north and/or west. However, this idea must be considered unlikely given the species' long presence in NSW and its proven mobility in other coastal areas.

Broad-scale occurrences in rainforest types of the listed tree species

Vernon (1985) tried to distinguish between those tree species unmistakably of dry rainforest and those of sub-tropical rainforest. She found that there was by no means complete agreement between the authorities, Floyd (1960–1982, 1983a & b, 1984) and Williams (1975–1980, 1982), as to which was which. She commented on page 57:

The criteria for classifying species in this way appear to be vague and are based largely on the experience of both Floyd and Williams ... There are as yet no objective guidelines by which to decide whether a species can more appropriately be classed as subtropical or dry. Therefore attempts to identify gradations from one rainforest subform to another, both within each study stand and from one stand to another, will necessarily be somewhat arbitrary and subjective.

We decided to use Floyd (1989) as the latest authority, to examine the broad-scale occurrence across the various rainforest types of the tree species observed in our survey (Table 17). We have combined some of Floyd's categories of individual rainforest types. Ninety-one tree species are included. Of those listed in Appendixes 2 and 3, the following were excluded:

1. those whose main occurrences are not in rainforest (*Brachychiton populneus*, *Casuarina cunninghamiana*, *Melaleuca quinquenervia* and *M. styphelioides*)
2. those with some claim to being of rainforest affinity (ecologically and/or taxonomically) but which are not dealt with in Floyd's book (*Geijera parviflora*, *Hymenanthera dentata* and *Notelaea microcarpa* var. *microcarpa*).

Based on Floyd's assessment, more than half of the tree species referred to in Table 17 are wide-ranging in their occurrence in rainforest in NSW. Their cosmopolitan presence does not impose any distinctive character on the stands examined. However, also present are twenty-three species whose main occurrences are in dry rainforest, and it is these which firmly place the surveyed stands in the dry rainforest category. Numbers in the remaining groups are small and show only a minor presence of sub-tropical- and warm temperate-favouring species. Nevertheless, although the modal class of average annual rainfall of these stands is only 800–899 mm, the tree floral list covers a wide range of preferred rainforest types — it is a very mixed assemblage, missing only species which prefer cool temperate rainforest. As a confirmation of the prevailing dry rainforest character of the stands, all of the twelve most abundant and frequent tree species of the survey (Table 11) occur in the left-hand half of Table 17, i.e. the 'dry and wide-ranging' side.

Cluster analysis of the stands

A dendrogram showing fusion sequences is set out in Figure 6. Only the final fourteen groupings have been retained for the figure — examination of smaller clusters did not yield any noticeable increase in interpretability in ecological or geographical terms.

Table 17. Assignment of the observed rainforest tree species to the broad rainforest types recognised by Floyd (1989)

GROUPINGS OF RAINFOREST TYPES						
Dry Rf alone	Dry Rf ± Littoral Rf Riverine Rf	Wide-ranging across all or most types	Sub-tropical Rf and Dry Rf ± Littoral Rf ± Riverine Rf	Sub-tropical Rf ± Gully Rf ± Littoral Rf Riverine Rf	Sub-tropical Rf and Warm- temperate Rf ± Riverine Rf	Warm- temperate Rf ± Littoral Rf Riverine Rf and/or Rf margins
NUMBER OF SPECIES (Total: 91)						
11	12	50	3	5	6	2
<i>Croton verreauxii</i> *	<i>Capparis arborea</i> *	(The top 12 spp. of 50 spp.)	<i>Dendrocnide excelsa</i> *	<i>Dysoxylum fraserianum</i>	<i>Toona ciliata</i>	<i>Glochidion ferdinandi</i>
<i>Brachychiton discolor</i>	<i>Hibiscus heterophyllus</i>	<i>Streblus brunonianus</i> *	<i>Sarcomelicope simplicifolia</i>	<i>Daphnandra micrantha</i>	<i>Citronella moorei</i>	<i>Tristaniaopsis laurina</i>
<i>Cleistanthus cunninghamii</i> *	<i>Cassine australis</i>	<i>Baloghia inophylla</i> *	<i>Ehretia acuminata</i>	<i>Brachychiton acerifolius</i>	<i>Pennantia cunninghamii</i>	
<i>Ficus rubiginosa</i>	<i>Alectryon subcinereus</i>	<i>Mallotus philippensis</i> *		<i>Podocarpus elatus</i>	<i>Emmenosperma alphitonioides</i>	
<i>Austromyrtus acmenoides</i>	<i>Olea paniculata</i> *	<i>Notelaea longifolia</i>		<i>Symplocos thwaitesii</i>	<i>Rapanea howittiana</i>	
<i>Backhousia sciadophora</i>	<i>Drypetes australasica</i> *	<i>Claoxylon australe</i> *			<i>Cinnamomum oliveri</i>	
<i>Alchornea ilicifolia</i>	<i>Rhysoetochia bifoliolata</i>	<i>Geijera salicifolia</i> *				
<i>Croton insularis</i>	<i>Melia azedarach</i>	<i>Clerodendrum tomentosum</i>				
<i>Maytenus sylvestris</i>	<i>Ficus superba</i>	<i>Diospyros australis</i>				
<i>Codonocarpus attenuatus</i>	<i>Canthium coprosmoides</i>	<i>Planchonella australis</i>				
<i>Canthium odoratum</i>	<i>Myoporum acuminatum</i>	<i>Diploglottis australis</i>				
	<i>Ficus fraseri</i>	<i>Elaeocarpus obovatus</i>				
		<i>Elattostachys nervosa</i> *				

* The 12 most abundant and frequent species, as listed in Table 11.

Table 18. Stand characteristics of some of the clusters delineated in Figure 6

Cluster (refer to Figure 6)	Number of stands	Area of stand (ha)		Number of tree species/stand	
		Mean	±Standard deviation	Mean	±Standard deviation
Western stands*	5	10.6	±6.9	42.6	±3.6
Northerly stands and rich and large stands	12	32.2	±19.6	56.8	±9.1
Mostly Central sector stands	13	16.2	±15.5	42.9	±4.8
Mostly Eastern sector stands	13	15.8	±15.4	45.2	±5.2

* Exclusive of Wg data, for which there is no single stand area.

Of the two large groups defined before the final fusion, the one on the left side consists of more readily interpretable sub-groups than that on the right side. The six most westerly of the stands are clearly separated from all others in terms of floristic similarity. Then, the most northerly stands occur together but are close to what we term 'rich (in tree species) and large (in area)' stands. The reason why these latter two sub-groups should be closely similar is not clear to us.

On the right side of the dendrogram, we can detect only what seems to be a trend, rather than a clear-cut demarcation of stands with particular characteristics within the sub-groups. The sub-groups on the left consist of more Central sector stands than Eastern (eight to five), while the tendency is exactly reversed in the sub-groups on the right. A look at some stand characteristics across sub-groups of the dendrogram (Table 18) shows that there are no great differences between those on the right side but that the stands of the 'rich and large' sub-group (combined with the three northerly stands) are markedly richer and larger on average than the stands of other sub-groups.

Overall, this analysis, as far as it has been taken, indicates that most stands in the Central and Eastern sectors form a large group which is not readily differentiated into sub-groups on ecological or geographical bases. The stands separated in floristic similarity from this large group are those which occur on the western and northern peripheries of the surveyed area and some of those which are richest in tree species and relatively large in area.

Results

c) Human influences

General observations on disturbance

There seems to be no broad-scale clearing — nor timber-getting — going on any longer in the rainforest stands of the survey area. However, many cases were seen where rainforest has been damaged by track-making activities. Sometimes, too, the best or only remaining eucalypt stems (used for fence posts) remaining on a property are at the edges of rainforest stands and logging tracks may be put in without thought to damage being done to the stand itself.

Another way in which direct damage can occur is as a result of epiphyte collection. The edges of some of the surveyed stands seem to be particularly prone to this kind

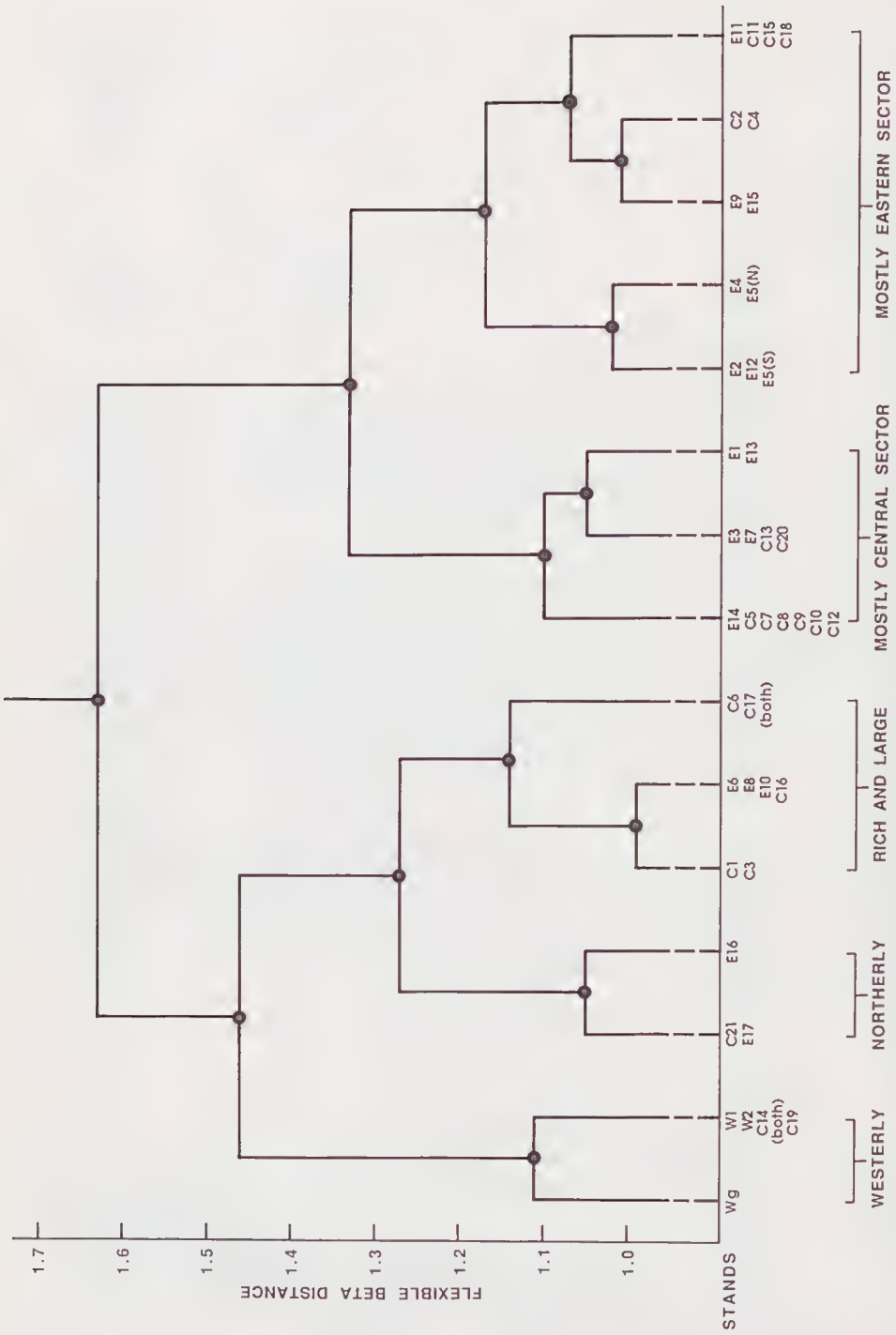


Figure 6. Dendrogram of groups of stands resulting from flexible-beta clustering procedure. Beta = -0.25.

of disturbance, probably because of their closeness to one or other public roads. In a few cases, trees were seen (particularly *Dendrocnide excelsa*, Giant Stinging Tree) which had probably been felled for their load of epiphytes.

Fires are often lit in hill pastures in this area, particularly in early spring, to encourage the rapid growth of new grass. Such fires seldom or never penetrate to the central parts of rainforest stands — however, by burning up to the edges of stands, they may cause the death of many rainforest seedlings and saplings. It is possible that the changed fire regime since white settlement has on balance been more damaging to rainforest edges than the pre-settlement regime.

Cattle seem not to browse on most rainforest plants — at least on those older than saplings — but they trample soils and plants, particularly at the edges of stands. Cattle tend to use the edges of stands for shelter — in a small stand, this may mean that no part of the stand is free of the disturbance resulting from trampling and the concentration of droppings.

Finally, there is the presence of the weed *Lantana camara* in and around most of the stands in the eastern half of the survey area (it occurred in three-quarters of the surveyed stands). The light requirements of *Lantana* are such that it is most successful around the edges of stands and below canopy gaps. The danger from such a vigorous competitor is that, over decades and longer, it will begin to diminish seriously the regeneration success of native species, especially of the rarer ones. Its long-term effect may well be to reduce the diversity of individual stands, and perhaps even to cause some local extinctions of rainforest species.

The condition of stand margins

Past forest-clearing activities have turned most of the survey area into a grassland in which scattered eucalypt trees remain. In this altered landscape, the margins of many rainforest stands now abut directly on to pasture. A stand margin in this situation must be regarded as being more at risk from potential disturbance than one where a belt of open-forest remains to act as a buffer. All of the surveyed stands were examined from this point of view, using both the sketch maps prepared at the time of ground survey and colour transparencies from plane flights. A sequence of five categories of relative 'protection' of stand margins by eucalypts was defined and each of the forty-six stands was assigned to a category (Table 19).

This examination indicates that most of the surveyed stands still have at least some contact at their margins with remnants of eucalypt-dominated open-forest. Indeed, most stands have fairly substantial buffer zones of eucalypts. There is a need for study of the whole subject of the pattern and condition of fragments of open and closed forests in this area in relation to effective plant and animal conservation.

Discussion

Botanical features

The surveyed stands form a fairly homogeneous unit within the dry rainforest sub-formation. Cluster analysis showed that there is some tendency to differentiation, especially on the western and northern peripheries of the survey area — however, it seems not to be strongly pronounced.

The total area of the forty-six surveyed stands is some 850 ha, with a median stand area of 15 ha. Some hundreds of other stands were not examined. This broad sweep

Table 19. Summary of extent of occupation by eucalypts of the margins of the surveyed rainforest stands

Eucalypt occupation of stand margins*	% of Stands in each category			
	Eastern Sector	Central Sector	Western Sector	All stands
(1) None	0	8	0	4
(2) Narrow eucalypt fringe along < half of periphery	30	12	50	22
(3) Narrow eucalypt fringe along ≥ half of periphery	15	17	50	17
(4) Substantial eucalypt stand along < half of periphery	25	33	0	28
(5) Substantial eucalypt stand along ≥ half of periphery	30	29	0	28
	100	99	100	99
Total number of rainforest stands assessed	20	24	2	46

* Further description of the categories:

(1) No more than occasional isolated mature eucalypts on stand margin.

(2) and (3) Continuous fringe of mature eucalypts, but no more than 25 m wide.

(4) and (5) There is an adjoining mature eucalypt stand which is at least 100 m wide and which has an area of at least 1 ha. There may or may not be, as well, fringing eucalypts of categories (2) or (3).

of stands in the Hunter Valley is the southernmost occurrence in Australia of a substantial area of floristically and structurally well-developed dry rainforest. There are elements of this rainforest type as far south as the South Coast of NSW, but they are much attenuated in extent, composition and complexity compared with the stands in the Hunter Valley. An illustration of this attenuation can be found in the southern limits of some of the tree species important in Hunter Valley stands. Those five 'abundant and frequent' trees identified in Table 17 as being known to be predominantly dry rainforest species (i.e. from the two columns at the left hand side of that table), are important in imposing a dry rainforest identity on the stands in the Hunter Valley (as well as on stands further north). Of these species, only *Croton verreauxii* has its southern limit outside the Hunter Valley. Together with *Brachychiton discolor*, also a dry rainforest species and the emergent tree with the highest inter-stand frequency in the surveyed stands, the other species have their limits within the survey area or immediately to the south of it (Floyd 1989).

Conservation considerations

None of the species listed in Appendixes 2 and 3 is on the rare or threatened plants list of Briggs and Leigh (1988). The main concern in conservation terms is that as many stands as possible in the survey area should remain structurally and floristically intact in the long term. At present the prognosis is not favourable because almost all the surveyed stands are on freehold land. The main exception is a part of Stand E8, Pilchers Mountain, which is a Crown Reserve for Recreation and which has already been recommended for Nature Reserve status by Floyd (1983a). From his limited survey, Floyd also recommended as worthy of conservation the Moonabung Falls (C1) and Cabbage Brush Creek stands (the latter is 4.5 km north-north-west of Moonabung Falls). Clearly, many other stands are worthy of protection and the current conservation status of the remaining rainforest across the survey area is highly unsatisfactory.

Fortunately, however, there is a clearly discernible trend amongst land-owners for the development of a sense of long-term care for the welfare of their land. Many of the owners encountered during the survey expressed great interest in the stands under survey. We believe that lack of specialised knowledge and advice, as well as a lack of financial incentive from governments, often inhibits conservation action by landowners. The recent growth of the Land Care movement is a welcome development from this point of view.

Within the survey area at present, the situation pertaining to the care of eucalypt-dominated open-forest is as unsatisfactory as that for dry rainforest. An ecologically-attractive possibility would be the planned conservation of tracts containing the two vegetation types in contact with each other, each in good condition. The notion of the value of a eucalypt forest buffer around the margin of a rainforest stand was raised earlier. Clearly, the idea could be extended so that appropriately-located examples of foothill eucalypt forest could be conserved in their own right. The preservation of a network of side-by-side residual stands of the two forest types across a broad sweep of country is an ideal to aim at.

Acknowledgements

The work reported here was supported by the National Estate Program, 1984/85 and 1985/86 (Project No. 37). The help of the following people during the course of the project is gratefully acknowledged: Brian Guilfoyle for the initial impetus and early planning, Trevor Stephens for safe and responsive piloting of Cessna aircraft, several enthusiastic helpers who accompanied one of us (SV) on field-trips, Laurie Henderson, Colin Harden and Olivier Ray-Lescure for cartographic and drafting work, Dr L.N. Morris for identification of and comment on rock samples, Kevin Stokes for guidance in the identification of ferns, the various land-owners for permission to enter their land and Sharon Parry for efficient word-processing.

References

- Beadle, N.C.W. (1971–1987) *Students flora of north eastern New South Wales*. Parts 1 to 6 (University of New England: Armidale).
- Bowden, D.C. & Turner, J.C. (1976) A preliminary survey of stands of temperate rainforest on Gloucester Tops. *Research Papers in Geography* 10 (University of Newcastle).
- Briggs, J.D. and Leigh, J.H. (1988) *Rare or threatened Australian plants: 1988 revised edition*. Aust. National Parks and Wildlife Service, Special Publication No. 14.
- Bridgman, H.A. (1984) *Climatic atlas of the Hunter Region*. Board of Environmental Studies Research Paper No. 9 (University of Newcastle).
- Chalmers, A.C. and Turner, J.C. (1994, in press) Climbing plants in relation to their supports in a stand of dry rainforest in the Hunter Valley, New South Wales. *Proc. Linn. Soc. NSW*, 114.
- Fisher, H.J. (1980) *The rainforests of the Liverpool Range, NSW*. Ph.D Thesis, University of Newcastle.
- Floyd, A.G. (1960–1982) *NSW rainforest trees, Parts I–XII*. Forestry Commission of NSW Research Note Series.
- Floyd, A.G. (1983a) *Dry rainforest outliers, Dungog–Maitland*. Unpublished Report (National Parks and Wildlife Service of NSW).
- Floyd, A.G. (1983b) *Rainforest vegetation of the Yessabah Limestone Belt and Carrai Plateau*. Unpublished Report (National Parks and Wildlife Service of NSW).
- Floyd, A.G. (1984) *Rainforests of Wollemi and Goulburn River National Parks*. Unpublished report (National Parks and Wildlife Service of NSW).
- Floyd, A.G. (1989) *Rainforest trees of mainland south-eastern Australia* (Inkata: Melbourne).
- Floyd, A.G. (1990) *Australian rainforests in New South Wales. Vol. II* (Surrey Beatty: Sydney).
- Fraser, L. & Vickery, J.W. (1938) The ecology of the upper Williams River and Barrington Tops

- districts. II. The rainforest formations. *Proc. Linn. Soc. NSW* 63:139–184.
- Galloway, R.W. (1963) Geology of the Hunter Valley. Pp. 81–89 in R. Story et al. *General Report on the Lands of the Hunter Valley*. CSIRO, Land Research Series No. 8 (CSIRO: Melbourne).
- Gambrill, G.G. (1986) *Rainforests on basalt caps, northern Wollemi area, New South Wales*. Ph.D Thesis, University of Newcastle.
- Graaf, R.H.M. van de (1963) Soils of the Hunter Valley. Pp. 103–135 in R. Story et al. *General Report on the Lands of the Hunter Valley*. CSIRO, Land Research Series No. 8 (CSIRO: Melbourne).
- Harden, G.J. (ed.) (1990) *Flora of New South Wales. Volumes 1, 2 & 3* (NSW University Press: Sydney).
- Rotherham, E.R., Briggs, B.G., Blaxell, D.F. & Carolin, R.C. (1975) *Flowers and plants of New South Wales and southern Queensland* (Reed: Sydney).
- Specht, R.L. (1970) Vegetation. In G.W. Leeper (ed) *The Australian environment* (CSIRO: Melbourne).
- Story, R., Galloway, R.W., Graaf, R.H.M. van de, & Tweedie, A.D. (1963) *General Report on the Lands of the Hunter Valley*. CSIRO, Land Research Series No. 8 (CSIRO: Melbourne).
- Turner, J.C. (1976) An altitudinal transect in rainforest in the Barrington Tops area, N.S.W. *Aust. J. Ecol.* 1:155–174.
- Turner, J.C. & Vernon, S.L. (1990) *Survey of rainforest stands between Barrington Tops and the Hunter River*. Unpublished Report, prepared for National Estate Grants Program (Australian Heritage Commission).
- Vernon, S.L. (1985) *Dry rainforests of the Hunter Valley: a comparative study*. B.A. Hons. Thesis, University of Newcastle.
- Webb, L.J. (1978) A general classification of Australian rainforests. *Australian Plants* 9: 349–363.
- Williams, J.B. (1975–1980) *Dorrigo National Park: dry rainforest and marginal dry rainforest* Unpublished Report (Department of Botany: University of New England).
- Williams, J.B. (1982) *A checklist of the rainforest flora of New South Wales* 2nd edn, (Department of Botany: University of New England).
- Williams, J.B., Harden, G.J. & McDonald, W.J.F. (1984) *Trees and shrubs in rainforests of NSW and Southern Queensland* (Department of Botany: University of New England).
- Williams, W.T. (1976) Pattern analysis and statistics. In W.T. Williams (ed) *Pattern Analysis in Agricultural Science* (CSIRO: Melbourne, and Elsevier Scientific: Amsterdam).

Manuscript received 21 December 1992

Manuscript accepted 6 September 1993

Appendix 1. Information about the stands: location and some physical features**EASTERN SECTOR**

Code designation	Stand name	Map sheet (1: 25 000) and grid reference	Area of stand (ha)	Altitudes of upper and lower margins (m)	Topographic type
E1	Mt Douglas	Paterson, 748 992	6	130–240	Down-stream valley site
E2	Glen Martin	Clarence Town, 909 004	2.5	50–140	Single gully-head
E3	Stony Creek, Wallarobba	Gresford, 750 043	17	100–210	Weakly-gullied rocky slopes
E4	Three Brothers: North Face	Dungog, E Stand: 893 040 W Stand: 895 040	E Stand: 4 W Stand:	110–170 80–160	Both stands: gully-head amphitheatres
E5	Three Brothers: Small Hill to North	Dungog, N Stand: 898 049 S Stand: 898 046	N Stand: 2 S Stand: 3	110–210 60–120	N Stand: gully-head amphitheatre S Stand: single gully-head
E6	Mirari Creek, Mt Ararat	Gresford, 725 055	19	100–240	Down-stream valley site
E7	Wallaringa Rd	Gresford, 771 071	8	180–230	Weakly-gullied rocky slopes
E8	Pilchers Mountain	Gresford, 765 100	32	230–350	Gully-head amphitheatre
E9	Coxs Gully	Gresford, 735 109	40	170–250	Down-stream valley site
E10	Tabbil Creek	Gresford, 737 131	84	170–430	Multiple gully-heads
E11	Wallarobba Range: West Side	Gresford, 734 143 (point central to both stands)	N Stand: 28 S Stand:	120–360 120–320	Both stands: multiple gully-heads
E12	Bingleburra	Gresford, 676 145	9	90–230	Single gully-head
E13	Wallarobba Range: NE Section	Gresford, 741 155	67	150–310	Multiple gully-heads
E14	Lewinsbrook	Gresford, 675 171 (at junction of Gresford and Allynbrook sheets)	21	120–330	Single gully-head
E15	Dog Trap Creek	Allynbrook, 668 175	19	130–370	Single gully-head
E16	Brandy Creek	Allynbrook, 706 219	23	170–370	Multiple gully-heads
E17	Chichester Gap	Chichester, 678 346	38	220–530	Multiple gully-heads

CENTRAL SECTOR

C1	Moonabung Falls	Paterson, 608 929	25	50–130	Down-stream valley site
C2	Rosewood Gully	Paterson, 641 944	4.5	110–170	Down-stream valley site

CENTRAL SECTOR (continued)

Code designation	Stand name	Map sheet (1: 25 000) and grid reference	Area of stand (ha)	Altitudes of upper and lower margins (m)	Topographic type
C3	Sandy Water-holes Creek	Elderslie, 474 962	16	190–380	Multiple gully-heads
C4	The Valley	Elderslie, 587 976	20	160–330	Single gully-head
C5	Lambs Valley	Elderslie, 553 986	6	130–300	Single gully-head
C6	Billy Brook	Elderslie, 519 985	23	120–310	Multiple gully-heads
C7	Lees Mountain	Paterson, 471 017 (also partly on Elderslie)	11	120–310	Weakly-gullied rocky slopes
C8	Summerhill Rd: N end	Ingar, 581 038	11	110–320	Down-stream valley site
C9	Mirannie Mtn: SE side	Ingar, 452 047	13	170–390	Single gully-head
C10	Mt Tyraman	Ingar, 568 052	4.5	190–360	Down-stream valley site
C11	Oakvale	Ingar, 488 079	14	140–300	Single gully-head
C12	Dark Hole	Ingar, 561 100	17	140–390	Gully-head amphitheatre
C13	Harris Creek	Ingar, 565 115	19	150–340	Gully-head amphitheatre
C14	Mt Dyrning	Ingar S Stand: 358 126 Cent. Stand: 364 132 N Stand: 368 134	S Stand: 5 C Stand: 7.5 N Stand: 3.5	240–400 210–400 230–380	S Stand: multiple gully-head C Stand multiple gully-head N Stand single gully-head
C15	Fenwicks Creek	Ingar, 547 137	16	200–300	Single gully-head
C16	Coulston	Gresford, 619 146	59	110–370	Multiple gully-heads
C17	Upper Myall Creek	Ingar, W Stand: 517 148 E Stand: 528 146	W Stand: 35 E Stand: 14	270–420 250–390	W Stand: gully-heads E Stand: single gully-head
18	Dry Creek	Ingar, 558 152	15	135–240	Down-stream valley site
C19	Breakneck	Carrowbrook, 417 181	22	270–500	Multiple gully-heads
C20	Mt Razorback	Allynbrook, 588 204 (also partly on Carrowbrook sheet)	10	270–420	Weakly-gullied rocky slopes
C21	Masseys Creek	Carrabolla, 568 314	19	200–490	Multiple gully heads

WESTERN SECTOR

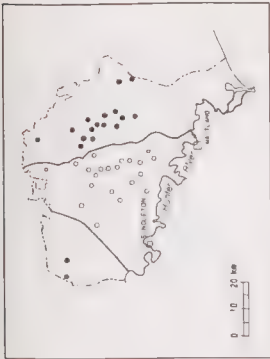
W1	Foy Brook	Dawsons Hill, 228 230	15	250–410	Down-stream valley site
W2	Cedar Creek	Dawsons Hill, 143 244	5	325–430	Gully-head amphitheatre

Appendix 2

Notes

- For locality and other information about the individual stands, see Appendix 1.
 - Estimates of relative abundance are presented using the following code:

VC	Very common
C	Common
O	Occasional
R	Rare, Very infrequent.
 - Taxa are arranged alphabetically at family, generic and specific levels within the structural categories of Trees, Shrubs, Herbs, Climbers and Epiphytes-Lithophytes.
 - * indicates an introduced species, now naturalised. The stands E5(S) and E5(N) occur very close together. They are identified according to their relative north-south locations. Both E4 and E11 also represent pairs of stands but only a combined species list was obtained for each.
 - The final column, Wg, is a general list of those rainforest-related species in the western sector observed to occur singly, in small groups and in small stands. No Herb or Epiphyte-Lithophyte presence lists were obtained for Wg.
- Arthropteris tenella* and *Microsorium scandens*, usually regarded as epiphytes (e.g. Beadle, 1971), have been placed here in the structural category of Climbers.



RAINFOREST STANDS

[illegible]

EASTERN AND WESTERN SECTORS

TREES

Alangiaceae	<i>Alangium villosum</i>
Anacardiaceae	<i>Euroschinus falcata</i>
Araliaceae	<i>Polyscias elegans</i>
Boraginaceae	<i>Ehretia acuminata</i>
Capparaceae	<i>Capparis arborea</i>
Celastraceae	<i>Cassine australis</i> var. <i>australis</i>
	<i>Maytenus silvestris</i>

Appendix 2. (continued)

EASTERN AND WESTERN SECTORS

RAINFOREST STANDS

	E1	E2	E3	E4	E5	E5 S N	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	W1	W2	Wg
Ebenaceae	O	C	R	O	O	O	O		O	O	O	O	R	O	O	C	C		C	O	O
<i>Diospyros australis</i>																					
<i>D. pentamera</i>	C		R				O	O	O	O		O			O			R		O	
Elaeocarpaceae	R	R		O	O		O	O	R	R	O		O	R	R	R	O	R	O	O	C
<i>Elaeocarpus obovatus</i>																					
<i>Sloanea australis</i>								R									C				
Euphorbiaceae	O						O	VC	C	C	C	O	C	O						C	O
<i>Actephila lindleyi</i>		O		O			O	O	O	O	O	O	O	O	O	C	O			C	O
<i>Alchornea ilicifolia</i>	O	VC	O	C	C	C	VC		VC		C	O	O	O	O	R	C	C	C	C	R
<i>Baloghia inophylla</i>	O	C	O	O	O	R	C	C	C		C	O	O	C	C	O	O	C	C	V	R
<i>Claoxylon australe</i>	O	O	R	O	O	R	C	O	O	O	VC	VC	C	VC	O	O	O		C	C	
<i>Cleistanthus cunninghamii</i>																					
<i>Croton insularis</i>							O	O		V	O	R		R		O	R				
<i>C. verreauxii</i>	O	O	O	C	V	R	C	O	O	C	O	O	O	O	O	C	VC	O	O	O	O
<i>Drypetes australasica</i>	C	C	VC	C	C	O	VC		C	R	O	O	O	O	C	O	C			O	
<i>Glochidion ferdinandi</i>																					
<i>Mallotus philippensis</i>	C	VC	VC	C	C		O	O	R	O	C	VC	VC	C	VC	V	VC	O	VC	O	O
<i>Omalanthus populifolius</i>	R							C	C	C						C	R		R	V	O
								V		V	C										
Eupomatiaceae				R			R		R												
Eupomatia laurina																					
Flacourtiaceae	R		R	O	O	R	O	R	R	R					R		R	O	R	O	O
<i>Scolopia braunii</i>																					
Gyrostemonaceae											O										
<i>Codonocarpus attenuatus</i>																					
Icacinaeae				C	R		R	R	R	R		R					O	R			
<i>Citronella moorei</i>																					
<i>Pennantia cunninghamii</i>	R						R	O	R									O	R	O	

Appendix 2. (continued)

Sapindaceae	<i>Alectryon subcinerus</i>	O	R	R	C	O	O	O	R	O	R	R	O	C	O	O	C	C	C
	<i>A. tomentosus</i>	O	C						O	R	R	O	R	O					
	<i>Diploglottis australis</i>	R	C	R	C		R		O	O	R	O	R	O	R	O	C	R	O
	<i>Elattostachys nervosa</i>	O	O	R	O	O	C	VC	VC	R	C	O	C	C	C	VC	C		
	<i>Guioa semiglauc</i>	R			O	O			R	O	R	R	R	R		O	O	R	R
Sapotaceae	<i>Mischocarpus australis</i>								O	O	O	R	O	R	R	O			
	<i>Rhysoetochia bifoliolata</i>	R	C	C	C	VC			O	R	O	R	R	R	R	O			
									C										
	<i>Planchonella australis</i>	R	O	O	O	O	O	O	O	O	O	O	O	R	O	VC			
Sterculiaceae	<i>Brachyichiton acerifolius</i>	O	R						O	O	R	R		O	C	O	R	R	
	<i>B. discolor</i>	O	O			R			O	O	O	O		O	C	O		C	
	<i>B. populneus</i>	R		R	R				O						R				
	<i>Commersonia fraseri</i>			R					R	O						R			
	<i>Celtis paniculata</i>	O	C						C	C	O			C					
Urticaceae																			
Urticaceae	<i>Dendrocnide excelsa</i>	C	C	O				VC	C	C	O	C	VC	C	C	C	C	V	O
	<i>D. photinophylla</i>	C	C					O	C	C	R	O	C	C	O	R		C	
									R										
Verbenaceae	<i>Clerodendrum tomentosum</i>	R	O	O	O	O	O	O	O	O	O	O	O	R	R	R	O	C	O
Violaceae	<i>Hymenanthera dentata</i>																O	O	O
SHRUBS																			
Amaranthaceae	<i>Deeringia amaranthoides</i>	O						O	R	R	O	O	R	O				R	
	<i>Nyssanthus diffusa</i>								R	R	O		O	O					
	<i>Senna floribunda</i>	R																	
	<i>Sambucus australasica</i>	R	O	O	O	O	R	R	R	R	R	R	R	R	R	R	O	O	
	<i>Breynia oblongifolia</i>	R	O	O	O	O	R	R	R	R	R	R	R	R	R	R	O	O	C
Malvaceae	<i>Abutilon oxycarpum</i>	O	C					R	O	R	R	O	O	O	O				

[illegible]

CLIMBERS

Аросунасеае

Parsonsia straminea

P. velutina

Gymnema pleiadenium

Marsdenia flavescens

M. rostrata

AA 1160dii:

Asteraceae ★

Delairea odorata

Pandorea pandorana

Celastraceae

Celastrus australis

C. subspicata

Aphanopetalum resinosum

Arthrarteris tenella

Dioscoreaceae

Dioscorea transversa

Fabaceae

Austrosteenisia blackii

Appendix 2. (continued)

Menispermaceae	<i>Legnephora moorei</i>	R	VC	C	O	O	O	C	C	C	C	C	C	C	C	C	O	
	<i>Sarcopetalum harveyanum</i>							R	R	R								
	<i>Stephania japonica</i>	R					R	R						R	O	O	O	
Moraceae	<i>Maclura cochinchinensis</i>	O	O	O	O	O	O	O	O	R	O	R	O	O	O	O	O	O
	<i>Malaisia scandens</i>	O	C	O	O	C	C	VC	C	O	O	O	O	O	R	R	O	C
Myrsinaceae	<i>Embellia australiana</i>	C		O				C	O	O	R			O	O	R	O	
Oleaceae	<i>Jasminum volubile</i>	O	VC	VC	V	VC	C	O	V	C	O	C		R	O	O	C	O
Passifloraceae	<i>Passiflora edulis</i>																	
	<i>P. herbertiana</i>										O					R		R
	<i>P. subpeltata</i>															R		
Piperaceae	<i>Piper novae-hollandiae</i>										O	O	R	R		R		
Polypodiaceae	<i>Microsorium scandens</i>							O	C									
Ranunculaceae	<i>Clematis glycinoides</i>							O	R	R						R		
Rosaceae	<i>Rubus hillei</i>															O		
	<i>R. moorei</i>	R						R						R	R	R		O
Rubiaceae	<i>Morinda acutifolia</i>																	
	<i>M. jasminoides</i>							C	O	O	R	O		R	C	O	O	R
Smilacaceae	<i>Eustrephus latifolius</i>	O	R	O	O	O	O	R	R	R	O	O	O	R	O	R		C
	<i>Geitonoplesium cymosum</i>																	
	<i>Ripogonum album</i>	R						O	R	R						O		
	<i>Smilax australis</i>	O		O				O	R	R	R	R	R	R	R	O	O	C
Vitaceae	<i>Cayratia clematidea</i>	O						R	R	O	R		R	O	R	O	O	
	<i>C. eulynema</i>									O								
	<i>Cissus antarctica</i>	V	C	C	C	C	C	VC	C	C	VC	VC	VC	C	VC	VC	C	C
	<i>C. hypoglauca</i>	C	R		R			R						C	R	R	O	
	<i>Tetrastigma nitens</i>	O	C	C	C	C	C	C	O	C	C	C	C	C	O	C	C	C

Appendix 2. (continued)

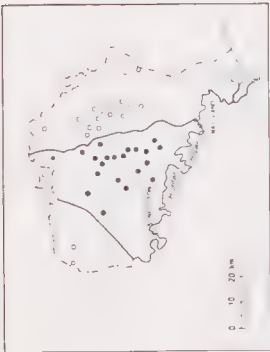
EPHYPHYTES and LITHOPHYTES

Aspleniaceae	<i>Asplenium attenuatum</i>	R	O	R	R	O	R	O	O	O	O	R	R	R	R	C	—
	<i>A. australasicum</i>					C		O		O		R					—
	<i>A. polyodon</i>					R											—
Davalliaceae	<i>Davallia pyxidata</i>							R									—
Orchidaceae	<i>Cymbidium suave</i>							R									—
	<i>Dendrobium gracilicaule</i>	O	R			C	R	O	O	O		R		R			—
	<i>D. linguiforme</i>	R	R		O	R	R	R									—
	<i>D. schoeninum</i>									O							—
	<i>D. speciosum</i>	R	R	R	O	C	O	C	R	O	O	O	O	R	O	R	—
	<i>D. teretifolium</i>		R			R			O	R	R	R	R				—
	<i>Liparis</i> sp.							R	R								—
	<i>Plectorrhiza tridentata</i>																—
	<i>Rhinerhiza divitiflora</i>							R	R	R							—
	<i>Sacrochilus falcatus</i>		R			O	O	O	O	O	O	R	R	O	R		—
Piperaceae	<i>Peperomia leptostachya</i>	R			O	C	O	R	O	C		R	O	R	O		—
	<i>P. tetraphylla</i>					C	O			O							—
Polypodiaceae	<i>Dictymania brownii</i>					C		R	O	R							—
	<i>Platyterium bifurcatum</i>	R	R		R	O	O	O	R			R	O	O			—
	<i>P. superbum</i>	R				C	O	O	O	O		O	R	O	R		—
	<i>Pyrosia confluens</i>	O	O	O	C	C	VC	O	O	O	C	O	R	C	O	O	—

APPENDIX 3
Central sector: list of species observed in the stands under examination

Notes

- For locality and other information about the individual stands, see Appendix 1.
- Estimates of relative abundance are presented using the following code:
VC Very common
C Common
O Occasional
R Rare, Very infrequent.
- Taxa are arranged alphabetically at family, generic and specific levels within the structural categories of Trees, Shrubs, Herbs, Climbers and Epiphytes-Lithophytes.
- * Indicates an introduced species, now naturalised.
- The three stands C14(S), C14(C) and C14(N) occur close together. They are identified according to their relative south-central-north locations. Here, only two species lists are presented: under C14(S), a combined list for C14(S) and C14(C) (separate lists not having been made when the field-work was done), and under C14(N) a list for that stand alone.
- The stands C17(W) and C17(E) occur close together. They are identified according to their relative west-east locations.
- The Herb and Epiphyte-Lithophyte presence lists for stand C2 are incomplete.
- *Arthropteris tenella* and *Microsorium scandens*, usually regarded as epiphytes (e.g. Beadle, 1971), have been placed here in the structural category of Climbers.



RAINFOREST STANDS

CENTRAL SECTOR																													
TREES					C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C14 S	C14 N	C15	C16	C17 W	C17 E	C18	C19	C20	C21	
Alangiaceae Anacardiaceae Araliaceae Boraginaceae Capparaceae		R	R	R													R			O	O	O	R	O			O	O	O
		R	R	O	O	O							R	R	R		O	R	R				O	O	R				
		R	O	O	O	C		R					O		O		R	O	O	O	R	R	O	R	R	O			C
		V	C	V	O	C	V	C	C	O	C		O	C	O	C	O	VC	V	O	C	C	C	C	C	C	C		O
		C	C	C		C													C										
		R																		C			R						
Casuarinaceae																													
															</														

RAINFOREST STANDS

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14 S	C14 N	C15	C16	C17 W	C17 E	C18	C19	C20	C21
Celastraceae	O	O	O	O	O	R	R	R	R	R	O	O	O	O	O	O	O	C	O	O	C	R	R
	O																						
Celastraceae																							

CENTRAL SECTOR

Celastraceae
Cassine australis var.
australis
Maytenus silvestris

Appendix 3. (continued)

[illegible]

Appendix 3. (continued)

Appendix 3. (continued)

CLIMBERS

[illegible]

Observations on the effects of mowing on native species in remnant bushland, western Sydney

T.A. James

James, T.A. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1994. *Observations on the effects of mowing on native species in remnant bushland, western Sydney* Cunninghamia 3(3): 515–519. Native plant species were recorded in 1989 from Gum Tree Reserve, a small area of remnant Turpentine–Ironbark Forest in western Sydney, after many years of frequent mowing. A further list was compiled in 1993, one year after a change to a less frequent mowing regime. Within this time the number of native species recorded increased threefold. Future management options are discussed with regard to encouraging further regeneration of native species and re-establishing the soil seed bank.

Introduction

Small bushland remnants in western Sydney are subject to many pressures as a result of their size and proximity to suburban housing. With an increasing need to preserve biodiversity in the suburban context (Benson & McDougall 1991), it is now recognised that such areas are important conservation sites for their scientific, ecological, educational and heritage values and should be managed to retain their native species. The 'tidying' of areas by mowing is a widespread management practice which may reduce overall native species richness (Kirkpatrick 1986). A reduction or elimination of mowing could, therefore, allow native species to re-establish and help prevent further decline in species richness. An opportunity arose to test this hypothesis at Gum Tree Reserve in a residential area of Guildford, western Sydney. The site had been mowed frequently, approximately six times a year, probably for up to 20 years prior to July 1992 (Water Board pers. comm.). A checklist of the area was compiled by the author during this period, in August 1989. Since July 1992 Holroyd City Council have opted for a regime of less frequent mowing. The site was mowed in July 1992 and subsequently in December 1992 with no further mowing to date (Holroyd City Council pers. comm.). The opportunity was taken to record the native species present at the site in June/July 1993 to assess any change in species richness resulting from the altered mowing regime.

Study site

Gum Tree Reserve is a 0.75 ha block of land in Harris Street, a residential area of Guildford, western Sydney, about 4.5 km south-west of Parramatta (33° 51' 12" S, 150° 58' 28" E), situated on the Cumberland Plain. The underlying geology is the Liverpool subgroup of Wianamatta Shale. The average annual rainfall is approximately 940 mm (Bureau of Meteorology 1979). The Reserve is a site of regrowth native woodland which, except for an adjacent Water Board pipeline corridor, is isolated by urban development. The nearest remnant bushland is at Duck Creek, Auburn, 3 km due east of the site, and at Prospect Creek, 2 km south-west of the site. The threat of development in the late 1980s motivated local residents to appeal to Holroyd City Council for conservation of the area as a local reserve.

The vegetation of the area is consistent with a drier form of Turpentine–Ironbark Forest once growing in districts west of Auburn (Benson & Howell 1990). The site is dominated by *Eucalyptus fibrosa* and *E. moluccana*, with occasional trees of *E. paniculata*, and one remaining tree each of *Syncarpia glomulifera* and *E. longifolia*. The understorey is poorly developed due to a history of clearing and regular mowing at the site. The few surviving small trees and shrubs include *Acacia parramattensis*, *Pittosporum undulatum*, *Bursaria spinosa*, *Rapanea variabilis* and *Maytenus silvestris*, most of which are located on the northern boundary of the reserve next to adjoining residences. Several exotic species (garden escapes) including *Tecoma capensis*, *Bryophyllum pinnatum* and *Bougainvillea* species have become established along this boundary. Holroyd City Council staff have recently planted several trees along the southern boundary (adjacent to pipeline corridor) including *Melaleuca linariifolia*, *M. styphelioides*, *Acacia floribunda* and *Eucalyptus* species. At least the first three species are native to the local area. Some trees of *Eucalyptus paniculata* may have been planted by the Water Board (D. Thomas pers. comm.).

Methods

Native plant species present in the reserve were recorded in August 1989, and subsequently during June–July 1993 by systematically walking the site. Observations on growth form, flowering/fruiting and means of regeneration were also made in June–July 1993.

Results

In 1989 when the site was regularly mowed, only 14 native species were recorded (Table 1). In contrast, in 1993 after a year of reduced frequency of mowing, a three-fold increase in the number of native species (14 to 45) was recorded. The regeneration of tree and shrub species was minimal, with only early stages of regrowth evident. However, there was significant regeneration of herbs, subshrubs and climbers, which accounted for 96% of the newly recorded species in 1993. Of the 45 species listed for Gum Tree Reserve, 68% are new records or have been recently recorded for the Holroyd Council area, and 13 species are considered vulnerable in western Sydney (Benson & McDougall 1991).

The dominant native grasses were perennial species including *Danthonia linkii*, *Digitaria parviflora*, *Paspalidium distans* and *Eragrostis leptostachya*, all of which were flowering or seeding at the time of the second survey. These species were well represented, particularly in areas away from the reserve boundaries, despite competition from exotic species including *Eragrostis curvula*, *Chloris gayana*, *Paspalum dilatatum*, *Sida rhombifolia* and *Plantago lanceolata*. Dominant species in the ground layer, other than grasses, were low-growing native shrubs, herbs and climbers with persistent rootstock and/or a stoloniferous habit including *Brunoniella australis*, *Einadia hastata*, *E. polygonoides*, *Dichondra repens* and *Glycine microphylla*.

As expected, there was minimal regeneration of tree and shrub species due to their longer life cycles. Limited suckering around the base of the *Eucalyptus* species was observed. The most extensive and vigorous regrowth of the larger shrub species was of *Maytenus silvestris* and *Rapanea variabilis*. Regeneration was primarily from existing rootstock, often in close proximity to the mature trees. Regeneration was also evident in *Polyscias sambucifolia*, *Pittosporum revolutum* and *Clerodendrum tomentosum*. The only seedlings observed were of *Acacia parramattensis*. Soil surface conditions appeared to

Table 1. Native plant species recorded from Gum Tree Reserve, Guildford in August 1989 following regular mowing (on average every 2 months), and in June/July 1993 after a change to a less frequent mowing regime. Regular mowing ceased in July 1992 with a 6 month break before a final mowing in December 1992.

Family	Species	Growth form	Aug 1989	Jun/Jul 1993	Regeneration
Monocotyledons					
ANTHERICACEAE	<i>Arthropodium milleflorum</i>	Gr		* Fr	R
CYPERACEAE	<i>Cyperus gracilis</i>	Gr		* Fl	R
JUNCACEAE	<i>Juncus usitatus</i>	Gr		* Fl	R
LUZURIAGACEAE	<i>Eustrephus latifolius</i> V	Cl		*	R
POACEAE	<i>Aristida vagans</i>	Gr		* Fl/Fr	R
	<i>Chloris truncata</i> V	Gr		* Fr	R
	<i>Danthonia linkii</i> var. <i>linkii</i> V	Gr		* Fl	R
	<i>D. racemosa</i> V	Gr		* Fl	R
	<i>Digitaria parviflora</i>	Gr		* Fl	R
	<i>Elymus scaber</i> V	Gr		*	R
	<i>Eragrostis leptostachya</i>	Gr		* Fl	R
	<i>E. sororia</i>	Gr		* Fl	R
	<i>Microlaena stipoides</i>	Gr		* Fl	R
	<i>Panicum simile</i>	Gr		* Fl	R
	<i>Paspalidium distans</i>	Gr		* Fl/Fr	R
	<i>Sporobolus creber</i> V	Gr		* Fl	R
	<i>Stipa rudis</i> subsp. <i>nervosa</i> V	Gr		* Fr	R
Dicotyledons					
ACANTHACEAE	<i>Brunoniella australis</i>	Gr		*	R
ARALIACEAE	<i>Polyscias sambucifolia</i> V	Sh		*	R
ASCLEPIADACEAE	<i>Tylophora barbata</i> V	Cl		*	R
ASTERACEAE	<i>Vernonia cinerea</i> var. <i>cinerea</i>	Gr		* Fl	R, ?S
BIGNONIACEAE	<i>Pandorea pandorana</i> V	Cl	*	*	R
CAMPANULACEAE	<i>Wahlenbergia gracilis</i>	Gr		*	R, ?S
CELASTRACEAE	<i>Maytenus silvestris</i>	Sh	*	*	R
CHENOPODIACEAE	<i>Einadia hastata</i>	Gr	*	* Fl/Fr	R, S
	<i>E. nutans</i>	Gr		*	R
	<i>E. polygonoides</i> V	Gr		* Fl/Fr	R, S
CONVOLVULACEAE	<i>Dichondra repens</i>	Gr		*	R
EUPHORBIACEAE	<i>Breynia oblongifolia</i>	Sh	* Fl/Fr	* Fl/Fr	R, ?S
FABACEAE (Faboideae)	<i>Desmodium varians</i>	Gr		*	R
	<i>Glycine microphylla</i> V	Cl		*	R
FABACEAE (Mimosoideae)	<i>Acacia parramattensis</i>	Tr	*	*	S
LORANTHACEAE	<i>Amyema</i> ?congener	Aerial parasite	*	*	
MYRSINACEAE	<i>Rapanea variabilis</i>	Sh	* Fl	*	R
MYRTACEAE	<i>Eucalyptus fibrosa</i>	Tr	* buds, Fr	* buds, Fr	R
	<i>E. longifolia</i> V	Tr	*	* Fl, Fr	(minimal suckering) R
	<i>E. moluccana</i>	Tr	* buds, Fr	* buds, Fr	(minimal suckering) R
	<i>E. paniculata</i>	Tr	* buds, Fr	* buds, Fr	(minimal suckering) R
	<i>Syncarpia glomulifera</i>	Tr	*	*	(minimal suckering) R
PITTOSPORACEAE	<i>Bursaria spinosa</i>	Sh	* Fr	* Fr	R, ?S
	<i>Pittosporum revolutum</i>	Sh	*	R	
	<i>P. undulatum</i>	Sh	*	*	None
RANUNCULACEAE	<i>Clematis glycinoides</i>	Cl	*	R	
SCROPHULARIACEAE	<i>Veronica plebeia</i>	Gr	*	R	
VERBENACEAE	<i>Clerodendrum tomentosum</i> V	Sh	*	R	

Key

V = vulnerable in western Sydney. Growth form: Tr= Tree, Sh= Shrub, Cl= Climber, Gr= Ground (herbs or subshrubs with renewal buds at or near surface). Regeneration = means of regeneration recorded: R = rootstock, S = seed, * = species present; Fl = flowers present; Fr = fruit present. Nomenclature follows Harden (1990-93).

be suboptimal for germination and seedling growth, with large areas exposed with dry, hard soil and minimal accumulations of organic matter.

Discussion

The 'new' species recorded in the second survey were predominantly herbs, subshrubs and climbers capable of vegetative regeneration. This is consistent with previous studies that indicate mowing will promote a community dominated by plants with renewal buds near or below the ground surface and with short life cycles (Buchanan, 1989). These resprouters may have been present at the time of the initial survey but were not readily identifiable due to frequent defoliation by mowing. It is unlikely that recolonisation from the adjacent Water Board corridor or other remnant vegetation in the district could satisfactorily explain the documented increase in native species richness. Although c. 100 native species have been recorded from upper sections of the pipeline corridor (D. Thomas 1993), only 37% were also recorded at the study site.

The lack of seedlings could indicate that the soil seed bank has been severely depleted due to long-term mowing of the site, although some seed may be dormant awaiting favourable conditions for germination and establishment. The long-term viability of seed for different species is poorly documented, but estimates for *Acacia* species may be as high as 50 to 100 years (New 1984). The high percentage of grasses and herbs flowering or fruiting at the time of the second survey indicates a significant potential input to the soil seed bank within 12 months of the change of mowing regime. Further investigations including documentation of the size, composition and viability of the soil seed bank are needed.

To allow significant tree and shrub regeneration there should be no mowing for several years. In the longer term, a reduced mowing regime may need to be implemented to address concerns regarding both the appearance of the site and any potential fire hazard. Mowing could occur once every two or three years or when there is a high fire risk, at least along the northern boundary adjacent to local housing. A mosaic mowing regime may be feasible whereby selected areas are mowed at different frequencies and/or heights. This approach could reduce fire hazards where needed, provide some public access, protect regenerating trees and shrubs, and promote the growth of herbs and subshrubs. Mowing may also be useful in the control of some weedy species, but the timing, frequency and height of cutting must be closely related to the phenology of individual species. The use of control burning could also be considered, although there are limitations with the small size of the area and the close proximity of housing.

Conclusions

The present species composition of the woodland in Gum Tree Reserve suggests that the site was once part of a western outlier of Turpentine-Ironbark Forest. There are no other examples of this vegetation type existing in the local district today and consequently, despite its small size, it is of significant heritage and scientific value. The botanical significance of the site is highlighted by the large proportion of native species not previously recorded in the Holroyd Council area and 13 species considered vulnerable in western Sydney (Benson & McDougall 1991).

The long history of frequent mowing at the site is likely to have resulted in the loss of some native species. Conditions favour the persistence of species with protected renewal buds, persistent underground rootstock and short life cycles. An increase in species richness (14 to 45 species) was documented within 12 months of the change in mowing regime. This increase is probably chiefly due to regeneration of these persistent species which were not readily identifiable in the initial survey. The possibility of some degree of recolonisation from the adjacent pipeline corridor also exists. Regeneration was primarily by vegetative means. The soil seed bank may be severely depleted or a small store of dormant seeds may exist awaiting favourable conditions. A major limitation of the survey is the absence of a control area that has not been mowed for comparison. The effect of other environmental factors, therefore, cannot be eliminated.

To restore the original vegetation of the site, natural regeneration must be encouraged. This could be achieved by stopping all mowing at the site for an initial period of 1–2 years and then instituting an infrequent or mosaic mowing regime. Maximum protection should be given to regenerating trees and shrubs. Additional management practices including the propagation of vegetative or seed material collected from the site should be considered. Exotic species need to be controlled within the reserve, particularly along the northern boundary where garden escapes have become established.

Despite the limitations of the study, the results indicate that reduced frequency of mowing can have positive effects on native species richness. The apparent persistence of many native species despite long-term mowing is of interest. The implications of these results for the management of urban bushland areas by local councils warrants recognition. It is important that detailed documentation of such remnant bushland is undertaken and appropriate priorities and management practices adopted.

Acknowledgements

I would like to thank Doug Benson, Phillip Kodela and Dr Surrey Jacobs for valuable comments on the manuscript and David Thomas of the Water Board for useful information on the local area. Holroyd City Council provided details of recent mowing practices at the site.

References

- Benson, D. & Howell, J. (1990) *Taken for granted: the bushland of Sydney and its suburbs* (Kangaroo Press: Kenthurst).
- Benson, D. & McDougall, L. (1991) *Rare bushland plants of western Sydney* (Royal Botanic Gardens: Sydney).
- Buchanan, R.A. (1989) *Bush regeneration: recovering Australian landscapes* (TAFE: New South Wales).
- Bureau of Meteorology (1979) *Climatic survey Sydney region 5: New South Wales* (AGPS: Canberra).
- Harden, G.J. (ed.) (1990–93) *Flora of New South Wales* Vol. 1–4 (New South Wales University Press: Kensington).
- Kirkpatrick, J.B. (1986) The viability of bush in cities — ten years of change in an urban grassy woodland. *Australian Journal of Botany* 34: 691–708.
- New, T.R. (1984) *A biology of acacias* (Oxford University Press: Oxford).
- Thomas, D. (1993) Lower canal vegetation survey. Water Board Report (Unpub.).

Manuscript received 3 August 1993

Manuscript accepted 15 December 1994

The effect of time since fire on the cover and composition of cryptogamic soil crusts on a eucalypt shrubland soil

D.J. Eldridge and R.A. Bradstock

D.J. Eldridge¹* & R.A. Bradstock² (¹Department of Conservation & Land Management, PO Box 77, Condobolin, NSW 2877* ²NSW National Parks & Wildlife Service, PO Box 1967, Hurstville, NSW 2220) 1994. The effect of time since fire on the cover and composition of cryptogamic soil crusts on a eucalypt shrubland soil. *Cunninghamia* 3(3): 521–527. We investigated the cover and composition of cryptogams at a number of mallee (*Eucalyptus* spp.) sites with different periods of recovery since fire. Total cryptogam cover increased with time since fire, and maximum cover of 52% occurred at sites with 16 years of recovery since fire. Increasing the interval since fire increased the contribution of crustose lichen to total cover and decreased the contribution by algae. The results suggest that fires less than ten years apart are generally likely to maintain cryptogam cover at low (< 20%) levels and lead to a dominance by algae.

Introduction

Eucalypt shrublands occupy an extensive area of Australia, and their ecological and economic significance is well established (Noble & Bradstock 1989). Mallee eucalypts (*Eucalyptus* spp.) are restricted to aeolian soils (Eldridge 1986), which are weakly structured, highly erodible by wind and water, and characterised by low levels of organic matter and available nutrients. In these communities, cryptogamic soil crusts occupy large areas of ground between individual shrubs. These crusts, which comprise mosses, lichens, algae and liverworts, help to stabilise the soil surface against water erosion (Fletcher & Martin 1948, Eldridge & Greene 1994). Their presence is linked to changes in vascular plant survival and nutrient cycling (West 1990).

Fires are a feature of many semi-arid landscapes, and occur regularly in eucalypt shrublands of eastern Australia (Bradstock 1989, Noble 1984). As well as altering the structure and composition of the shrub and herbaceous layers, fires affect the cryptogamic components of the soil surface. Studies on different soil types in other semi-arid grazing systems (e.g. Greene et al. 1990, A.M. Gill pers. comm. 1993), have shown that fire has the capacity to destroy gels and mucilaginous sheaths associated with cryptogams and fungal hyphae in the crusts. This results in a breakdown in the spatial integrity of the crust, increased erosion (Kinnell et al. 1990) and reduced infiltration through a decline in aggregate stability and density of fungal hyphae (Greene et al. 1990).

Although the rate at which cryptogamic surfaces recover after fire has been variously reported in the literature for some soil and rangeland types, there are no data for aeolian soils. Reported rates for complete recovery in other systems vary from 4 years (Greene et al. 1990) to more than 20 years (Callison et al. 1985). In January 1992 we commenced a study to investigate the rate of recovery of cryptogamic soil crusts after fire, on an aeolian soil dominated by mallee species at a range of sites with different intervals since fire.

* Present address: Graduate School of the Environment, Macquarie University, NSW, 2109.

Methods

Study area

The study was conducted in eucalypt shrublands at Yathong, Round Hill and Nombinnie Nature Reserves in central-western New South Wales (Figure 1). The landscape is characterised by long undulating sandplains with slopes of $< 2\%$ on which are superimposed subdued low rises to 2 m in relief. Soils on the sandplains are predominantly calcareous sands (Uc5.12; Northcote 1979) and those on the rises an assortment of calcareous sands and siliceous sands (Uc1.13; Northcote 1979).

Vegetation was similar on the sandplains and rises, with a shrub overstorey dominated by stunted mallees (particularly *Eucalyptus socialis*, *E. dumosa*, *E. leptophylla* and *E. gracilis*) and a perennial shrub understorey dominated by *Acacia rigens*, *A. wilhelmiana*, *A. triptera*, *A. havilandii* and *Melaleuca uncinata*. *Callitris preissii* subsp. *verrucosa* was more common on the low rises, and *Triodia irritans* was locally dominant at all sites. Recently burnt sites possessed a ground layer composed of ephemeral forbs and grasses (e.g. *Haloragis odontocarpa*, *Goodenia* species, *Stipa* species.)

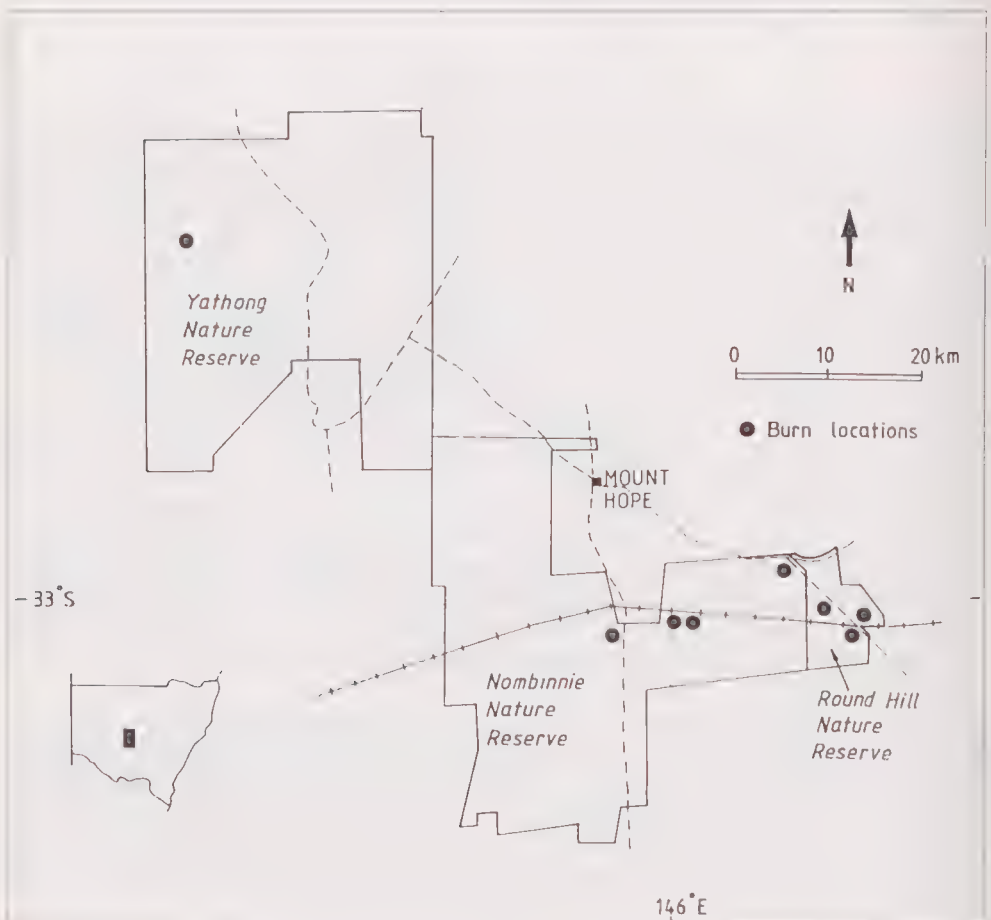


Figure 1. Location of the study areas in central-western New South Wales.

The fire treatments

In January and August 1992 we selected nine areas of mallee representing a broad range of fire histories. These areas represent times since last fire of 1, 3, 4, 7, 13, 16, 18, 35, and 100 years (Table 1). An additional block was measured 2 weeks after an experimental burn. Blocks varied in size according to fire history. Blocks at Yathong Nature Reserve (0, 1, 3 and 4 yrs) were either 100 X 100 or 200 X 200 m, and resulted from experimental fires (Bradstock et al. 1992). The 7, 13, 16, 18, 35 and 100 year fire histories were located on sites burned by wildfires and occurred over many hundreds of hectares. Fires in experimental blocks produced levels of fuel consumption and scorch in the vegetation that were visually similar to the study sites burnt by wildfires. Data for the 100 years since fire treatment were collected from three remnant areas of mallee dominated by *Callitris preissii* subsp. *verrucosa* located at Yathong (1 block) and Round Hill Nature Reserves (2 blocks). These remnant areas resulted from the progression of *Callitris preissii* subsp. *verrucosa* individuals from the understory into the overstorey, resulting in a diminution of fine fuel and hence fire frequency (Bradstock 1989, 1991). Time since fire in the these sites was indirectly estimated from size measurements of dominant *Callitris preissii* subsp. *verrucosa* individuals relative to younger plants of known age at other nearby sites (Bradstock unpublished data).

Measurements

At each site a transect was laid out through a homogeneous area of mallee, along which 20, 0.25 m² quadrats were systematically sampled at 10 m intervals. On the smaller experimentally burnt sites, transects were laid out along the two plot diagonals. Transects were located on the sandplain units except for the 100 year treatments which traversed the small rises. One observer estimated the total cover of cryptogams, and the relative contribution to total cover of moss, algae and lichens. Previous studies (Eldridge 1993) have verified the accuracy of this method for estimating species composition. We have no data however on the composition of various taxa on

Table 1. Changes in the composition (%) of moss, algae and lichen with time since last fire (years). n indicates the number of quadrats used in the calculations and sem is the standard error of the mean.

Time since fire (year)	Moss			Algae		Lichen	
	n	mean	sem	mean	sem	mean	sem
1	17	7.6	1.0	72.9	1.6	19.5	1.4
3	13	7.0	4.7	57.3	11.6	35.7	1.8
4	9	11.1	11.1	68.9	13.7	20.0	1.9
7	57	15.5	0.7	57.9	0.8	26.6	4.0
13	18	3.0	0.7	10.3	4.3	86.7	1.0
16	37	8.2	0.7	20.3	1.0	71.5	1.0
18	18	6.1	2.3	31.4	10.4	62.5	9.9
35	19	7.4	3.7	35.0	7.9	57.6	1.4
100	24	4.2	4.2	77.3	7.8	18.5	1.2

the plot at time zero. Apart from a general description of the main species found at the sites, we were only interested in broad cryptogamic taxa. Consequently cryptogams were pooled into either moss, lichens or algae.

Results

Fire resulted in a dramatic reduction in cryptogam cover from about 35% on a block last burned in 1985 (i.e. 7 years since fire) to 5% two weeks after fire. Cryptogam cover increased markedly with time since last fire, reaching a maximum of 52% at 16 years since fire. Cover then declined to < 2% at 100 years since fire. Within a single fire history, cryptogam cover was highly variable.

The moss flora at the sites was dominated by *Didymodon torquatus*, with smaller occurrences of *Bryum pachytheca*, *Desmatodon convolutus*, *Barbula hornschi*, *Gigaspermum repens* and *Eccremidium pulchellum*. The lichen flora comprised *Endocarpum* spp., *Collema* spp. and *Psora decipiens*. Some other unidentified lichen and algae were present at the sites.

Mosses contributed very little to total cover, and their contribution to total cover was generally < 10% through time (Table 1). Composition of algae within the cryptogamic layer however was greatest shortly after fire (73% after 1 year), declining to low levels due to a gradual replacement by lichens (Figure 2). The 100-year-since-fire sites were dominated almost exclusively by algae, although total cover was < 2%. One-way ANOVA revealed no significant differences in composition of moss, lichen or algae due to the large spatial variation in composition between quadrats at any given site.

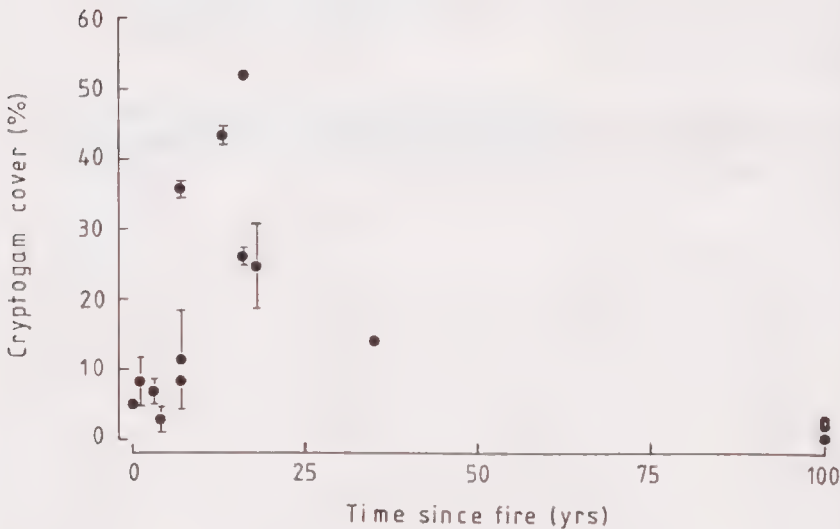


Figure 2. The relationship between total cryptogam cover (%) and time since last fire (years). Symbols enclose standard errors of the mean except where indicated.

Discussion

Non-vascular plants are primary stabilisers after major perturbations such as fire or grazing. In aeolian landscapes, where the post-fire soil surface is particularly unstable, largely due to saltating sand grains, little is known of the process of recolonisation by cryptogams after fire.

Effect of fire on total cover and composition

The results indicate that maximum cryptogam cover occurs 13–16 years after fire. At less than 7 years after fire, cryptogam cover is likely to be low (< 20%; Figure 1) and to be dominated by algae at the expense of lichen (Table 1). Fire failed to completely eliminate cryptogam cover on the plot measured two weeks after fire, as the main understory fuel *Triodia irritans* was only patchily distributed on the ground.

The only other data on post-fire recovery of cryptogams comes from studies on red earth soils in the semi-arid woodlands by Greene et al. (1990). These studies showed that cryptogam cover reached a maximum of about 60% four years after burning. This level probably represents the upper limit of cryptogam cover on red earth soils, and would be expected to decline in response to the development of stable cover of vascular plants. This maximum cover value is consistent with our observation of 52% for a sandy soil, but the time taken to achieve this was significantly greater in our study (13–16 years, Figure 1). Johansen et al. (1984) showed that there were still marked reductions in cover and frequency of moss, algae and lichen five years after burning. Similarly West and Hassan (1985) showed only partial recovery of moss and lichen from a Utah rangeland after 2 years. In a desert shrub community in Utah, Callison et al. (1985) reported that cryptogamic crusts had not recovered even 30 years after fire.

Greene et al. (1990) found that continual burning (yearly for 7 years) completely destroyed cryptogams. Micromorphological examination of the cryptogamic crust revealed that continual burning eliminated fungal hyphae and the gels cementing individual mineral particles together. In that study, fire led to a breakdown in the structural integrity and organic component of the soil crust, and to reductions in spatial heterogeneity at the soil surface. The slower recovery rates in our soils may have resulted from differences in lichen or algal taxa between the two sites (A. Downing pers. comm. 1993), due to different soil conditions between the two sites, or lower populations of fungi and blue-green algae in sandy soils. In a study of post-fire recovery of algal soil crusts in the USA, Johansen et al. (1993) observed that certain functional groups of algae were associated with specific soil pH levels. They postulated that these algal groups had different abilities to recover after fire. Differences in recovery might also have been due to the more hostile post-fire environment on the sandy soils which is dominated by wind-induced erosion.

The dynamics of cryptogam cover after fire is closely tied to their competitive advantage over vascular plants during the early stages of recovery, as well as their interaction with vascular plant recruits and the resprouting mallee shrub layer. During the first few years after fire in a eucalyptus shrubland, litter is generally low (Bradstock 1991), at which time algae are primary stabilisers of the soil surface. Blue-green algae have the capacity to fix atmospheric nitrogen, making this available to developing vascular plants (Rychert et al. 1978). Algal polysaccharides and fungal hyphae cement the soil particles into more stable units, providing a substrate for developing mosses and vascular plants. Coincident with an increase in nitrogen fixation and organic matter levels, mosses and lichens increase in cover. This increase in cryptogam cover up to

a maximum at 16 years corresponds with an increase in cover of understorey shrubs and *Triodia irritans* (Bradstock 1989). Despite the dominance of these shrubs in the lower strata, and the density of mallee eucalypts in the overstorey (Bradstock 1991, Bradstock & Gill in press), there are still large patches of bare ground between the shrubs for colonisation by cryptogams. However, after about 16 years post-fire, our results suggest that cryptogam cover begins to decline. This can be attributed to the spreading of litter from overstorey *Eucalyptus* species and *Callitris preissii* subsp. *verrucosa*, which, in the absence of fire, reduces the cover of bare ground and thus niches for colonisation by cryptogams.

As well as changes in total cover due to fire, we found differences in the relative composition of moss, algae and lichen, although these differences were not significant due to the high spatial variability. Our results suggest that frequent burning (i.e. less than once every 7 years) leads to the persistence of algae at the expense of moss or lichen (Table 1). This is consistent with work by Schulten (1985), who found that fire reduced the composition of mosses and lichens during the initial stages of recovery on a sandy soil in the Midwest of the United States.

Implications for management of mallee landscapes

As mallee landscapes support pasture plants of low grazing values, carrying capacities are as low as one sheep to 20 hectares (Noble 1984). The use of controlled burning in mallee shrublands is restricted under Regulation 50C(1)(j) of the Western Lands Act 1901. Current legislation, however, allows burning in eucalypt shrublands for the purpose of promoting the growth of pasture species or for reducing fuel loads, provided that the dominant eucalypt species are not killed. Similarly, fire is used by park administrators for hazard reduction and habitat manipulation. Our results suggest that the cover and composition of cryptogamic crusts will be dependent on the fire regime adopted by land managers, and this may affect the vulnerability of the surface to erosion. For example, under a regime of frequent fires where algae are dominant, wind and water erosion may increase, particularly in the absence of a high cover of vascular plants. Tchoupopnou (1989) showed that algal-covered surfaces were the least effective and lichen the most effective at reducing erosion. Increased diversity of cryptogamic flora on plots of 10–15 years since fire would result in an adequate cover of mosses and lichens, maximising soil microtopography, increasing surface detention, and decreasing rainsplash and erosion. There is value in the proposition of Good (1981) that management should be flexible, allowing for long fire-free periods in reserves, which would aid plant species conservation. An alternative strategy may be to proscribe certain events which are incompatible with the fundamental aim of conservation (e.g. frequent fires), but allow others to happen (e.g. wildfires or no fires) according to chance (Bradstock 1989).

Acknowledgements

The study was undertaken under a permit from the NSW National Parks and Wildlife Service. We thank Alison Downing for identifying the mosses and lichen and Stuart and Andrew Eldridge for assistance in the field.

References

- Bradstock, R.A. (1989) Dynamics of a perennial understory, pp 141–54 in J.C. Noble and R.A. Bradstock (eds) *Mediterranean landscapes in Australia: mallee ecosystems and their management*

- (CSIRO Australia: Melbourne).
- Bradstock, R.A. (1991) Relationships between fire regimes, plant species and fuels in mallee communities, pp 218–23 in J.C. Noble, P.J. Joss & G.K. Jones (eds) *The mallee lands: a conservation perspective* (CSIRO Australia: Melbourne).
- Bradstock, R.A., Auld, T.D., Ellis, M.E. & Cohn, J.S. (1992) Soil temperatures during bushfires in semi-arid, mallee shrublands. *Aust. J. Ecol.* 17: 433–40.
- Bradstock, R.A. & Gill, A.M. (in press) Fire in semi-arid mallee shrublands: size of flames from discrete fuel arrays and their role in the spread of fire. *Intern. J. Wildland Fire* 3.
- Callison, J., Brotherson, J.D. & Bowns, J.E. (1985) The effects of fire on the blackbrush (*Coleogyne ramosissima*) community of southwestern Utah. *J. Range Mgmt.* 38: 535–38.
- Eldridge, D.J. (1986) *Aeolian soils of South Western New South Wales* (Soil Conservation Service of NSW: Sydney).
- Eldridge, D.J. (1993) Cryptogams, vascular plants and soil hydrological relations: some preliminary results from the semi-arid woodlands of eastern Australia. *Great Basin Naturalist* 53: 48–58.
- Eldridge, D.J. & Greene, R.S.B. (1994) Microbiotic soil crusts: a review of their roles in soil and ecological processes in the rangelands of Australia. *Aust. J. Soil Res.* 32: 389–415.
- Fletcher, J.E. & Martin, W.P. (1948) Some effects of algae and molds in the rain-crust of desert soils. *Ecology* 29: 95–100.
- Good, R.B. (1981) The role of fire in conserving reserves, pp 529–50 in A.M. Gill, R.H. Groves and I.R. Noble (eds) *Fire and the Australian biota* (Australian Academy of Sciences: Canberra).
- Greene, R.S.B., Chartres, C.J. & Hodgkinson, K.H. (1990) The effect of fire on the soil in a degraded semi-arid woodland. I. Cryptogam cover and physical and micromorphological properties. *Aust. J. Soil Res.* 28: 755–777.
- Johansen, J.R., Ashley, J. & Rayburn, W.R. (1993) Effects of rangefire on soil algal crusts in semiarid shrub-steppe of the Lower Columbia Basin and their subsequent recovery. *Great Basin Naturalist* 53: 73–88.
- Johansen, J.R., St Clair, L.L., Webb, B.L. & Nebeker, G.T. (1984) Recovery patterns of cryptogamic soil crusts in desert rangeland following fire disturbance. *Bryologist* 87: 238–43.
- Kinnell, P.I.A., Chartres, C.J. & Watson, C.L. (1990) The effect of fire on the soil in a degraded semi-arid woodland. II. Susceptibility of the soil to erosion by shallow rain-impacted flow. *Aust. J. Soil Res.* 28: 779–94.
- Noble, J.C. (1984) Mallee, pp 223–40 in G.N. Harrington, A.D. Wilson and M.D. Young (eds) *Management of Australia's rangelands* (CSIRO Australia: Melbourne).
- Noble, J.C. & Bradstock, R.A. (1989) *Mediterranean landscapes in Australia. Mallee ecosystems and their management.* (CSIRO, Melbourne, Australia).
- Northcote, K.H. (1979) *A factual key to the recognition of Australian soils.* (Rellim Publications: Adelaide).
- Rychert, R.J., Skujins, D., Sorenson, D. & Porcella, D. (1978) Nitrogen fixation by lichens and free-living microorganisms in deserts, pp 20–30 in N.E. West and J. Skujins (eds) *Nitrogen in desert ecosystems* (Dowden, Hutchinson & Ross, Stroudsburg: Pennsylvania).
- Schulten, J.A. (1985) The effects of burning on the soil lichen community of a sand prairie. *Bryologist* 72: 110–114.
- Tchoupopnou, E. (1989) Splash from microphytic soil crusts following simulated rain. Unpub. M.Sc. thesis, Utah State Univ.
- West, N.E. (1990) Structure and function of microphytic soil crusts in wildland ecosystems of arid and semi-arid regions. *Adv. Ecol. Res.* 20: 179–223.
- West, N.E. & Hassan, M.A. (1985) Recovery of sagebrush-grass vegetation following wildfire. *J. Range Manage.* 38: 131–134

Manuscript received 24 June 1993

Manuscript accepted 15 December 1993

Lost and found: *Nothofagus moorei* at Comboyne *Print 66520*

C.L. Bale and J.B. Williams

Bale, C.L.¹ & Williams, J.B.² (¹New England Institute of TAFE, Armidale, NSW, Australia 2350; ²Botany Department, University of New England, NSW, Australia 2351) 1994. Lost and found: *Nothofagus moorei* at Comboyne. *Cunninghamia* 3(3): 529–533. A knowledge of the distribution and species associates of *Nothofagus moorei* (F. Muell.) Krasser is useful in elucidating the former distribution and significance of the species. Although previously thought to have been lost from Comboyne Plateau, *N. moorei* is now known to occur there in at least four small stands. The size distributions of *N. moorei* individuals and the floristics of these communities are reported together with a discussion of the significance of this extension to the known contemporary distribution of the species.

Introduction

Nothofagus is regarded as an ancient genus of great importance to Southern Hemisphere biogeography (Melville 1982, Hill 1992). *Nothofagus moorei* (F. Muell.) Krasser is a broad-leaved species of the subgenus *Lophozonia* (Hill 1992) and is one of the most geographically isolated species of the genus. This species occurs disjunctly on mountain, plateau, and escarpment positions in eastern Australia between the Barrington Tops area (latitude 32° 03' S) and the Lamington Plateau (latitude 28° 15' S). Floyd (1989) lists most of the known locations of *N. moorei* in New South Wales.

A detailed knowledge of the contemporary distribution of *N. moorei* is useful in several ways. As noted by Melville (1982), the present distribution of the genus is important in elucidating not only its former significance and distribution, but also in making broad paleoclimatic and paleobiogeographic inferences. At the species level, Bale and Williams (1993) showed that distributional and floristic data were useful in elucidating the refugial status and classification of communities dominated by *Nothofagus moorei*. Further, to achieve the kind of morphological and genetic data called for by Hill (1992), it is desirable to sample throughout the known range of *Nothofagus* species. An account of previously unknown contemporary occurrences of *N. moorei* on the Comboyne Plateau is thus warranted.

The Comboyne Plateau (Figure 1), centred on latitude 31° 36' S and longitude 152° 28' E, is a scarp-bounded paleoplain remnant located between the Great Escarpment and the seaboard on the central north coast of New South Wales (Pain & Ollier 1986). The plateau forms a low ramp from 450 m elevation in the north to about 700 m at the southern rim. Tertiary basalts overlie much of the plateau surface, giving rise to generally fertile krasnozemic soils. In the southern third of the plateau, some of the basaltic mantle has been removed, exposing the underlying Triassic sediments of the Lorne Basin. Drainage lines form a typical radial pattern. The Thone River, flowing north, and Mumfords Creek, flowing west, drain the largest catchments of the plateau surface.

The former natural vegetation of the Plateau was mostly 'Softwood Brush' (Chisholm 1925); now described as Subtropical Rainforest (Baur 1965) or Complex Notophyll Vine Forest (Webb et al. 1984). Almost all of the original vegetation was removed in the first quarter of this century, particularly from those parts of the plateau surface and benches where soils were richest. Only small samples of the original rainforest

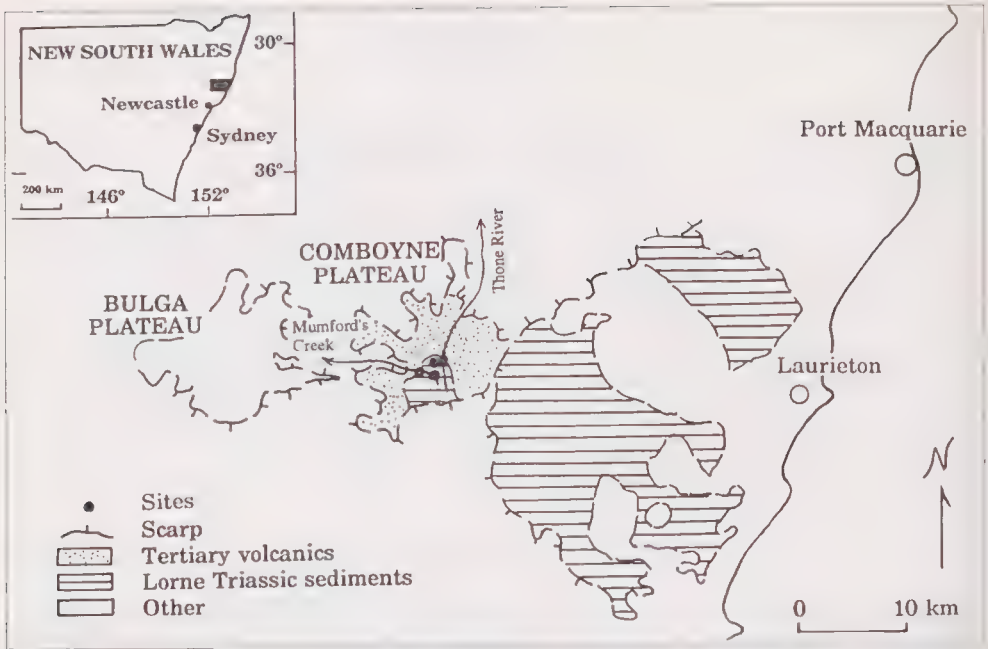


Figure 1. Location and geomorphology of the Comboyne Plateau and surrounding area (after Pain & Ollier 1986).

Table 1. Descriptions of four *Nothofagus moorei* sites at Comboyne

	Site 1	Site 2	Site 3	Site 4
Location	Thone River	Thone tributary	Mumfords tributary	Mumfords Creek
Site description	Surrounded by pasture. Cleared early 1900s.	Surrounded by pasture. Cleared early 1900s.	Stream-side remnant surrounded by pasture. Cleared early 1900s.	Stream-side rain-forest with large relic individuals. Some Coachwood extraction since 1940s.
Aspect	Level stream terrace	Level stream terrace	W	S
Altitude (m)	580	600	620	590
Stand size (m²)	200	200	1000	5000

Table 2. Floristic richness of four *Nothofagus moorei* sites at Comboyne

Lifeform	Site 1	Site 2	Site 3	Site 4
Trees & Shrubs	12(2 ^a)	16(4 ^a)	23(1 ^a)	27(3 ^b)
Lianas		0	2(1 ^a)	1(1 ^a) 5
Epiphytes	1	4	2	8
Herbs	2(2 ^c)	7(6 ^c)	8(6 ^c)	(4 ^c)
Total	15	28	34	47

^aIntroduced; ^bMarginal; ^cFerns.

cover remain, of which the stands at Boorganna Nature Reserve and Hills Brush are most notable.

The pioneering botanical survey of Comboyne by Chisholm (1925) is significant in many respects, but our attention was particularly drawn to his mention of '*Fagus moorei* (Negrohead Beech), which is extremely rare, although many trees were undoubtedly destroyed during clearing'. In recent years, the elusiveness of *Nothofagus* [*Fagus*] *moorei* has led some authors to the conclusion that it no longer survives at Comboyne. Based on the evidence of some associate species, Floyd (1990) surmised that *N. moorei* may have previously occurred on Mumfords Creek. Adam (1992) concurred that 'The absence (of *N. moorei*) from the Bulga and Comboyne Plateaux is explained by clearing early in the twentieth century'.

Recent investigations

During the past four years, several searches of selected parts of the Comboyne Plateau were made by us. Given the gallery rainforest habitat of *N. moorei* at similar altitudes at East Dorrigo, efforts were directed at searching similar sites at Comboyne. Searches of the southern and eastern escarpment of Comboyne and of the adjoining Bulga Plateau were also made. With the help of local residents we were able to discover that *Nothofagus moorei* still occurs on the Comboyne Plateau and to date four stands of *N. moorei* have been located. All are in gallery positions in the southern half of the Plateau. These range in size from two adjacent trees in otherwise cleared pasture to a relatively intact stand of more than 20 mature trees together with many juveniles and a range of associate species. Herbarium specimens NE 057405, NE 057406, and a duplicate lodged at the National Herbarium of NSW were collected at the latter site. In areas of apparently suitable environmental conditions on Bulga Plateau, no *N. moorei* occurrences have yet been found.

All four sites on the Comboyne Plateau were found high in the catchments of Mumfords Creek and the Thone River at elevations of between 570 and 630 metres (Table 1). Our observations indicated that none of the sites occurs directly on the basalt-derived eutrophic soils. Rather they occurred on soils derived from either the Lorne Basin sediments, or the contact between these rocks and the overlying volcanics. It was likely however that at some sites soils contained basaltic contributions from upslope caprock. At these relatively low altitudes, it appeared that the gallery positions of sites are critical in providing *N. moorei* with cool moist micro-climates and abundant soil moisture.

Site floristics

Species lists were compiled at all sites, and a summary of floristic richness is presented in Table 2. Vascular species richness increased with stand size, although the number of species of trees and shrubs differed little between the two Mumford sites, despite marked differences in site histories. Substantial numbers of liane and epiphyte species occurred only at Site 4 (Mumfords Creek), indicating that this site has attained a greater structural integrity than the others. At all sites, ferns dominated the herb stratum.

At Site 1 (Thone River), the only tree species associating with *N. moorei* were *Tristania collina*, *Acacia melanoxylon* and *Callicoma serratifolia*. *Doryphora sassafras* occurred as an occasional sapling. Site 2 (Thone tributary) was similar to Site 1, although the shrub layer was floristically richer and *Callicoma serratifolia*, although locally abundant, was absent from the stand. *Lomatia arborescens* was the most prominent small tree at this site. Much of the nearby streambank was infested with exotic

species such as *Ligustrum sinense* and *Solanum mauritianum*, and these species had invaded the small *N. moorei* stand. Much of the floristic complement of Site 2 was also present at Site 3 (Mumfords Creek tributary), together with many typical temperate rainforest species such as *Caldcluvia paniculosa* and *Schizomeria ovata*. Several small tree species of differing rainforest affinities occurred here too, including *Cryptocarya glaucescens*, *Lomatia arborescens* and *Backhousia myrtifolia*. *Cyathea australis* and *Todea barbara* were important shrubs. All of the foregoing species occurred at Site 4. At this location however, *Ceratopetalum apetalum* was codominant, and attained sole dominance in surrounding areas where *N. moorei* was absent. A feature of the floristics at Site 4 was the mix of species of microthermal and mesothermal affinity. *Quintinia sieberi*, *Alyxia ruscifolia* and *Orites excelsa* are typical associates of *N. moorei* at considerably higher altitudes, yet here they occurred with mesothermal elements such as *Guioa semiglaucula* and *Platynerium bifurcatum*. Common species typical of these mid-altitude sites on oligotrophic and mesotrophic soils included *Cryptocarya meissneriana* and *Acradenia euodiiiformis*.

Significance

The rediscovery of *N. moorei* at Comboyne is not significant in a historic biogeographic context; it has long been regarded as a former element of Comboyne rainforests. However, this find is important for other reasons. Firstly, it extends the contemporary distribution of *N. moorei* and provides some evidence that the species is of sufficient vagility to survive severe disturbance and fragmentation, despite here approaching its lower altitude limit and being somewhat remote from other populations. Secondly, it appears that at Comboyne *N. moorei* is fastidious in its site requirements, particularly in relation to site conformation. It is thus unlikely that *N. moorei* had extensive occurrences in the area. The impact of clearing and logging appears to have been in fragmenting perhaps already discontinuous ribbon-like galleries of these rainforests stands. In these situations *N. moorei* forms essentially stable assemblages with species of differing rainforest affinities. Many of these species are known to occur preferentially on oligotrophic and mesotrophic soils (Floyd 1990), or to have rather broad edaphic tolerances. The only other region known to us in which *N. moorei* routinely occupies similar topographic positions with a similar floristic complement is at East Dorrig (Bale & Williams 1993).

Thirdly, at least two of these stands of *N. moorei* are of importance because they demonstrate a considerable dependence on seedling recruitment (Table 3). Whilst many old relic individuals are multistemmed or support well-developed coppices, field checks have established that a substantial component of the younger cohorts were seedling-derived. It appears that under the disturbance regimes at Comboyne, site conditions promote successful *N. moorei* seedling responses. The spread of individuals through seedling and juvenile cohorts suggests that positive seedling responses have occurred over many decades. We expect that seedling recruitment will diminish as disturbance-recovery proceeds and that individual replacement will then be maintained by coppicing.

Finally the stands of *N. moorei* at Comboyne are notable in that they represent a second low-altitude domain of the species. To our knowledge, the only other area in which *N. moorei* occurs below 650 m elevation is at East Dorrig (Bale & Williams 1993). Whether or not any significant genetic differences occur between these low altitude populations and the much larger populations of the high plateaus and escarpment areas of northern New South Wales is currently being investigated. Should it eventuate that the extent of *N. moorei* forests is diminished by climatic change, then these low-altitude populations may be useful, both as *in situ* indicators of change, and as a genetic resource which might migrate to higher elevations.

Table 3. Numbers of individuals in size cohorts, largest individuals, and abundance of coppices in *Nothofagus moorei* stands at Comboyne (seedlings and some saplings verified as genets)

	Site 1	Site 2	Site 3	Site 4
Size Cohort				
Mature (> 20 m tall)	2	2	8	23
Semi adult (10-20 m)	0	0	5	19
Sapling (2-10 m)	0	0	> 40	21
Seedling (< 2 m)	0	2	8	5
Diameter of largest individual (cm)	60	26*	70	150
Relative abundance of coppices	—	+	++	+++

* Largest stem of multi-stemmed individual

Acknowledgements

We are grateful to Mr C. Amos and Mr D. Billingham for assisting us in locating these stands of beech. Several landowners are thanked for providing access to private property.

References

- Adam, Paul (1992) *Australian Rainforests* (Clarendon Press: Oxford).
- Bale, C.L. & Williams, J.B. (1993) Composition and classification of *Nothofagus moorei* communities in northern New South Wales. *Australian Systematic Botany* 6: 429–440.
- Baur, G.N. (1965) *Forest Types in New South Wales*. NSW Forestry Commission Research Note, No. 17. (Forestry Commission of New South Wales: Sydney).
- Chisholm, E.C. (1925) The Comboyne Plateau: its general conformation and flora. *Proceedings of the Linnean Society of New South Wales* 50: 284–298.
- Floyd, A.G. (1989) *Rainforest Trees of Mainland South-eastern Australia*. (Inkata Press: Melbourne).
- Floyd, A.G. (1990) *Australian Rainforests in New South Wales*, Volume 11. (Surrey Beatty: Sydney).
- Hill, R.S. (1992) *Nothofagus*: evolution from a southern perspective. *Tree* 7: 190–194.
- Melville, R. (1982) The biogeography of *Nothofagus* and *Trigonobalanus* and the origin of Fagaceae. *Botanical Journal of the Linnean Society of London* 85: 75–88.
- Pain, C.F. & Ollier, C.D. (1986) The Comboyne and Bulga Plateaus and the Evolution of the Great Escarpment in New South Wales. *Journal and Proceedings, Royal Society of New South Wales* 119: 123–130.
- Webb, L.J., Tracey, J.G. & Williams, W.T. (1984) A floristic framework of Australian rainforests. *Australian Journal of Ecology* 9: 169–198.

Manuscript received 24 June 1993
 Manuscript accepted 14 March 1994

Observations on the ecology and conservation status of the rare herb *Gentiana wingecarribiensis*

Print 66527

P.G. Kodela, T.A. James and P.D. Hind

P.G. Kodela, T.A. James & P.D. Hind (Royal Botanic Gardens, Sydney NSW Australia 2000) 1994. Observations on the ecology and conservation status of the rare herb *Gentiana wingecarribiensis*. *Cunninghamia* 3(3): 535–541. *Gentiana wingecarribiensis* L. Adams (Gentianaceae) is a rare, short-lived herb endemic to Wingecaribee Swamp in the NSW Central Tablelands (34° 34' S, 150° 31' E). Population estimates were made over two seasons and observations on distribution, growth and habitat recorded. Population numbers are low, with the Gentian restricted to a narrow ecotone area on the swamp margin. Specific regeneration requirements, poor seed dispersal and lack of competitiveness may help to explain its rarity. The survival of *G. wingecarribiensis* depends largely on protection of the ecotone area between the swamp and surrounding grassland, particularly from extreme and/or sudden changes in water level. Management strategies and recommendations are provided.

Introduction and methods

Gentiana wingecarribiensis L. Adams (Gentianaceae) is a small, short-lived annual or ephemeral herb recorded only from Wingecaribee Swamp (34° 34' S, 150° 31' E), about 5 km WNW of Robertson on the Central Tablelands of New South Wales. It was first reported in the early 1960s by A.R.H. Martin, with herbarium specimens collected during November 1967 by P. Bates, and L.A.S. Johnson and B.G. Briggs. Further collections were made in 1971 and 1973, and it was described by L.G. Adams in Adams & Williams (1988). It was not, however, until 1992 that new interest emerged and it was found again by P.D. Hind and colleagues of the National Herbarium of NSW and the NSW National Parks & Wildlife Service.

Gentiana wingecarribiensis is assigned a conservation status code of 2E in the Australian rare or threatened plant list (Briggs & Leigh 1988). The 2 implies the species has a geographic range less than 100 km; E implies it is considered to be endangered with a serious risk of becoming extinct over the next few decades. In view of the threatened status of *G. wingecarribiensis*, a brief study was undertaken to compile further information on its distribution and ecology. Using site information from herbarium collections and communications with several past collectors, suitable areas were searched at Wingecaribee Swamp. Population estimates and observations relating to distribution, stage of growth, associated species and habitat characteristics were made for each site. Potential sites in other wetland habitats in the district were also briefly searched.

Plant description

Gentiana wingecarribiensis is an erect, glabrous herb to 11 cm high in flower, with opposite, ovate, sessile leaves 2–9 mm long. The 1–9 flowers are solitary, terminal and usually open in succession over a period of 2–3 months from October. Opening of the corolla (anthesis) occurs in bright sunlight (photonastic) and/or possibly as a response to change in temperature (thermonastic). The corolla is narrow-campanulate,

10–17 mm long, greenish-ribbed outside and purple-blue inside (Fig. 1). The distinctive capsule has a flared, 2-lipped apex (Fig. 2); seeds are numerous, 0.25–0.35 mm long. More complete descriptions are provided by Adams & Williams (1988) and Harden (1992).

Gentiana wingecarribiensis is one of four species of *Gentiana* recorded in Australia, all belonging in *Gentiana* section *Chondrophyllae* Bunge. This is a typically montane and predominantly Northern Hemisphere group, the southern limit of which is significantly extended by the Australian species (Pringle 1979, Adams & Williams 1988). All four species occur on the New South Wales tablelands and are considered endangered or vulnerable (Adams & Williams 1988).

Distribution and site characteristics

Wingecarribee Swamp is a large, montane peatland or fen at 680 m alt., supporting a complex of vegetation types and diverse flora (Hope & Southern 1983, Kodela & Hope 1992). The catchment is predominantly of Triassic Wianamatta Shale overlying Hawkesbury Sandstone with Tertiary basalt-capped hills mainly in the east.

In November 1992 three discrete, localised populations of *G. wingecarribiensis* were recorded on the southern side of the swamp. They were located in an ecotone area within 5–10 m of the swamp margin where the sedgeland, with some low shrubs, intergrades with the surrounding grassland/pasture. This micro-habitat on damp peat or peaty loam to clay loam supports a low, open vegetation cover 5–60 cm high, of predominantly sedges, grasses and other herbs, as well as woody subshrubs (Fig. 3). The soil was damp or occasionally saturated, but standing water was not evident. Earlier herbarium collections refer to a micro-habitat of low *Sphagnum* hummocks and at one of the three sites this was evident, the remaining sites being level ground. At one site there was marked disturbance from cattle trampling on the swamp periphery. Associated species included *Asperula* cf. *gunnii*, *Baumea rubiginosa*, *Carex* species, *Centella cordifolia*, *Comesperma retusum*, *Dichelachne inaequiglumis*, *Dichondra repens*, *Drosera peltata*, *Eriocaulon scariosum*, *Hydrocotyle peduncularis*, *Hypericum japonicum*, *Juncus planifolius*, *Leptospermum obovatum*, *Myriophyllum simulans*, *Prasophyllum uroglossum*, *Pratia surrepens*, *Pultenaea divaricata*, *Schoenus apogon*, *Thelymitra pauciflora*, *Themeda australis*, *Viola caleyana*, *Viola* species A (*V. hederacea* subspecies *fuscoviolacea*), *Wahlenbergia ceracea*, and the introduced species *Anthoxanthum odoratum*, *Holcus lanatus*, *Hypochaeris radicata*, *Lotus uliginosus*, *Sisyrinchium* species A and *Trifolium* species.

Much of the swamp is apparently unsuitable for *G. wingecarribiensis* due to a dense sedgeland or reedland cover and/or too high water levels. It has not been found at other potential sites in wetland habitats in the district, including Wildes Meadow, 4.5 km south of Wingecarribee Swamp, which has the most comparable environmental conditions.

Population size and biology

The location of individuals and estimation of population sizes is made difficult by the small inconspicuous appearance of the plants, the short life span of individuals and the flowers only opening in bright sunlight. During November–December 1992 the three identified sites had estimated populations of 36, 6 and 50 plants (estimates made by the NPWS were slightly higher, Cohn undated). The observed populations were highly localised, in areas of approximately 3 m x 3 m in sites 1 and 2 and c. 15 m x 3 m in site 3. Sites 1 and 2 were approx. 30 m apart, while site 3 occurs



Figure 1. *Gentiana wingecarribiensis* flowers over a period of 2–3 months from October. The corolla is only known to open in bright sunlight. All photos this page by D.W. Hardin.



Figure 2. The distinctive capsule of *Gentiana wingecarribiensis*.



Figure 3. *Gentiana wingecarribiensis* is now restricted to a narrow ecotone area on the margin of Wingecarribie Swamp where the vegetation is low in stature and relatively open.

c. 1.75 km due WNW of these sites. The individual plants had a scattered distribution within these sites. The Gentian was absent from adjacent areas with apparently similar habitat conditions.

In early November 1993 the estimated population at site 1 was approx. 30 plants. Individual plants were close to the previous year's population, indicating seeds are very locally dispersed. No plants were evident at the other known sites at this time or later in the season.

Gentiana wingecarribiensis flowers chiefly from October to December, but it was seen flowering in January 1988 (R. Bates pers. comm.). From our observations, flowering occurs in plants from 2.5 cm high, considerably shorter than the surrounding vegetation. Individual plants may have buds, flowers and capsules present at the same time. The capsules and seed appear to mature rapidly within about 1 month of flowering and the plants wither and die completely within about 2 months.

Land-use history

All the recorded sites for *G. wingecarribiensis* appear to be either on freehold land or on the border of freehold land and the swamp, which was acquired by the Water Board in June 1993. Although the sites are within an area zoned for Environmental Protection (Cohn undated) there is no control over agricultural use. The western part of the swamp was flooded in the mid-1970s for a reservoir, which is managed by the Water Board to supply water to local towns and occasionally Sydney. Drainage channels on the swamp are associated with mining and agricultural activities. Peat mining operations have been active in the western part of the remaining mire over the last 20 years. Surrounding slopes in the catchment are used for grazing of beef and dairy cattle. As a result of human disturbance and pasture improvement, there are many exotic plant species that occur mainly on the swamp margins and surrounding land. Much of the swamp vegetation appears to be subject to annual burns, usually in late spring, though several fires may occur in a year. The fires are often patchy, and observations suggest that the Gentian sites are mostly not affected.

Discussion

Despite the difficulties encountered in estimating the frequency and distribution of *G. wingecarribiensis* and the short period of observation, recent field assessments appear to confirm that the species is restricted to Wingecarribie Swamp and that population numbers are low. More specifically, the plant is restricted to a relatively narrow ecotone area on the swamp margin where the vegetation is low in stature and relatively open.

Despite the production of large quantities of seed in 1992 (hundreds of seeds are produced per capsule), low population numbers at site 1 in 1993 indicate either a low percentage germination or low seedling survival rate. These observations and the absence of germination at the other sites in 1993, suggest that seed may be stored in a persistent soil seed bank. Seeds of the European species *Gentiana verna* remain viable until the second season when germination is often better than the first (Elkington 1963). Overseas studies on *Gentiana* also indicate that a cold phase (e.g. freezing) is required for germination (Simmonds 1946, Elkington 1963). The germination requirements of *G. wingecarribiensis*, however, need further investigation.

The rarity of *G. wingecarribiensis* may be explained by a combination of factors. The highly localised populations and fluctuations in population numbers suggest that regeneration requirements for the species may be very specific. If local environmental conditions are unsuitable the seed may experience some degree of enforced dormancy. The ability to remain dormant in the soil for long periods is a recognised feature of plants inhabiting unstable environments (Fenner 1985), including swamps which experience fluctuations in water level. Under Raunkiaer's life-form classification *G. wingecarribiensis* is a therophyte, i.e. 'a plant that completes its life cycle rapidly during periods when conditions are favourable and survives unfavourable conditions (e.g. cold, heat, or competition) as seed' (Allaby 1992). The viability of populations will be further affected if plants are unable to successfully exploit potential sites. The appearance of individuals at site 1 in 1993, in the close vicinity of the previous year's population, suggests a clumping effect consistent with limited seed dispersal, though the minute and lightweight seed of *G. wingecarribiensis* might be conducive to wind dispersal. Pringle (1979) suggests that seeds of certain species of *Gentiana* could be dispersed as the wind shakes the open capsules. The low height of *G. wingecarribiensis*, however, may limit the effectiveness of this dispersal method in the absence of air turbulence. When the capsules are open in wet weather, seed dispersal could be assisted by rain-splash. Once seeds have left the capsules, there may be a possibility for lateral water dispersal if the watertable is above the ground near the plants at the time of fruiting or if they occur near local ponds or channels on the swamp. There are several records of *G. wingecarribiensis* occurring near the edges of channels.

Rapid plant growth and seed production is apparent, *G. wingecarribiensis* completing its life cycle in approx. 3 months. It is feasible that strong selection pressures could operate in favour of such rapid development considering the small size of the plants and their dependency on bright sunshine for anthesis. The early flowering period may have evolved to ensure optimal conditions before the later growth flush of taller sedges and grasses. In early December 1992 one population was located in relatively dense stands of *Themeda australis* and other herbs to 60 cm high, but only one month later no Gentian plants could be found.

Conservation and management

The long-term survival of *G. wingecarribiensis* is likely to depend on the maintenance of the micro-habitat found in the ecotone area of the swamp. Adams & Williams (1988, p. 168) state that 'viable populations are probably dependent on a stable habitat of short, damp turf of forbs, sedges, grasses and bryophytes' and 'its long-term survival could depend on the watertable remaining relatively high and fluctuating only within limits of a few centimetres for lengthy, and possibly critical, seasonal periods'. Prior to European settlement, grazing by native herbivores may have played an important role in maintaining short, open conditions in this type of habitat (Adams & Williams 1988). Today, over-grazing and trampling by cattle, as well as ground disturbance caused by heavy machinery such as tractors would be detrimental to such sites, particularly during the plant's growing season. Potential Gentian habitats have already been lost on the edges of the swamp where intensive trampling has created muddy, rough surface conditions.

Disturbance by fire or physical means, in the absence of grazing by native herbivores, may be a necessary management tool to reduce competition with other species, including weeds, and to promote an open vegetation structure that provides sufficient light and shelter for the Gentian. Such management recommendations were made by Bishop (1992) as a result of a survey of the rare orchid *Prasophyllum uroglossum*

which also occurs in this ecotone area of the swamp. A report of *G. wingecarribiensis* flowering on recently burned peat mounds late in the season (R. Bates pers. comm.), when sites may normally be overgrown with other species, supports this view. A fire shortly before the Gentian's growing season or subsequent to completion of fruiting could be beneficial; however, if the fire coincides with the flowering and fruiting stages the plants are likely to be killed.

Current land-use practices, i.e. peat mining, agriculture and use of part of the swamp as a reservoir may threaten the survival of *G. wingecarribiensis*. Major alterations in the watertable or changes in the hydrological regime, as well as grazing pressure and competition from exotic plant species appear to be the most critical factors. The Gentian appears to be sensitive to changes in water level and may have occurred more widely in areas now flooded by the reservoir. Damming would have also increased watertable levels in the remaining swamp, which may have affected the distribution of *G. wingecarribiensis*. This is supported by observations made by Martin (pers. comm.) in the early 1960s, which indicate that the Gentian was growing in central parts of the swamp prior to construction of the reservoir. Peat mining, drainage and cattle grazing and trampling, directly or indirectly, threatens the remaining suitable habitat. Changes in water quality and soil nutrient status are likely to have resulted from agricultural practices and peat extraction. The impacts of these changes on the Gentian and other wetland species need investigation.

The ecotone between the swamp and the grassland/pasture is of considerable conservation value, not only for the survival of *G. wingecarribiensis* but also for the rare and endangered *Prasophyllum uroglossum*, which also appears to be restricted to Wingecarabee Swamp. Additionally, species diversity is high in the ecotone as it is an overlap zone between two communities and may provide a refuge for marginal swamp species. The conservation of *G. wingecarribiensis* will depend on protecting its habitat in the ecotone area, including the maintenance of a buffer zone.

Management strategies and recommendations

Further investigation of the ecology of *G. wingecarribiensis* is warranted, particularly by monitoring population numbers over several years and investigating the impacts of burning and other land-use practices. To assess the long-term viability of the species, the size and longevity of the soil seed bank requires investigation. Seed germination trials should continue at Mount Annan Botanic Gardens and self-perpetuating populations be established in accordance with the Royal Botanic Gardens Plant Conservation Policy (Royal Botanic Gardens 1993). Considering the small size of populations at Wingecarabee Swamp, further collections should be limited and the impacts of human trampling associated with field studies considered.

The recorded sites of *G. wingecarribiensis* should be fenced for protection from grazing and trampling. Additional areas with similar habitat conditions could also be managed as potential Gentian sites. While grass mowing and slashing may be useful in maintaining open sites, such practices should be avoided during the Gentian's growing season i.e. October–January. The control of exotic plant species in these areas is important. The Blackberry *Rubus discolor*, for example, occurs on swamp margins near the Gentian sites. Methods for the control of woody weeds are outlined in Cohn (undated).

The survival of *G. wingecarribiensis* depends largely on protection of the swamp from extreme and/or sudden alterations of water levels resulting from land-use activities in the catchment. Watertable levels should be monitored and consideration given to the potential impacts of any manipulation of water levels and future works in Wingecarabee Reservoir. Any future expansion of the reservoir onto the swamp

could result in the loss of habitats crucial to the survival of *G. wingecarribiensis*. The designation of Wingecarribiee Swamp as a nature reserve, including a buffer zone, is recommended to increase protection of this rare and endangered species and the associated wetland communities.

Acknowledgements

We are grateful to Mr L.G. Adams of the Australian National Herbarium, Canberra, Drs L.A.S. Johnson and B.G. Briggs of the National Herbarium of NSW, Sydney, Dr A.R.H. Martin and Prof. R.C. Carolin formerly of Sydney University, and Mr R. Bates, Adelaide, for providing information on the distribution and ecology of *G. wingecarribiensis*. We thank Messrs L. Adams and Doug Benson for commenting on the manuscript. We thank Mr Bob Coveny for his valuable field assistance and botanical knowledge during several visits to the swamp. Photographs taken by Mr David Hardin are gratefully acknowledged. The School of Geography, University of NSW, supported P.G.K. during earlier visits to the swamp. This rare species will greatly benefit from investigations by the NSW National Parks & Wildlife Service, including a Conservation Research Statement and Recovery Plan prepared by Ms J. Cohn. This plan is currently being implemented by Ms M. Matthes of NPWS. We would also like to acknowledge the assistance of the Water Board, Department of Conservation and Land Management and Department of Mineral Resources. We thank Amgrow and landowners for allowing us access to the investigation sites.

References

- Adams, L.G. & Williams, J.B. (1988) *Gentiana* sect. *Chondrophyllae* (Gentianaceae) in Australia. *Telopea* 3: 167–176.
- Allaby, M. (ed.) (1992) *The concise Oxford dictionary of botany*. (Oxford University Press: Oxford).
- Bishop, A.D. (1992) Conservation of *Prasophyllum uroglossum* at Wingecarribiee Swamp: Report of survey 26/11/92 and recommendations for management. Unpubl. Report.
- Briggs, J.D. & Leigh J.H. (1988) *Rare or threatened Australian plants*. Special Publication No. 14. (Australian National Parks & Wildlife Service: Canberra).
- Cohn, J. (undated) *Recovery plan — research phase & conservation strategy: Gentiana wingecarribiensis* L. Adams. Australian National Parks & Wildlife Service Endangered Species Program Project No. 251. (NSW National Parks & Wildlife Service: Hurstville). Unpubl. Report.
- Elkington, T.T. (1963) *Gentiana verna* L. *Journal of Ecology* 51: 755–767.
- Fenner, M. (1985) *Seed Ecology*. (Chapman & Hall: London).
- Harden, G.J. (1992) Gentianaceae. Pp. 508–515 in G.J. Harden (ed.), *Flora of New South Wales* Volume 3. (New South Wales University Press: Kensington).
- Hope, G.S. & Southern, W. (1983) *Organic deposits of the Southern Tablelands region, New South Wales*. Unpublished report to the NSW National Parks & Wildlife Service, Sydney.
- Kodala, P.G. & Hope, G.S. (1992) *Wingecarribiee Swamp: statement of significance*. (National Trust of Australia (NSW): Sydney).
- Pringle, J.S. (1979) Taxonomy and distribution of *Gentiana* (Gentianaceae) in Mexico and Central America. II. sect. *Chondrophyllae*. *Sida* 8: 14–33.
- Royal Botanic Gardens Sydney (1993) *Plant conservation policy*. (Royal Botanic Gardens: Sydney).
- Simmonds, N.W. (1946) Biological flora of the British Isles: *Gentiana pneumonanthe* L. *Journal of Ecology* 33: 295–307.

Manuscript received 10 December 1993

Manuscript accepted 14 March 1994

Floristics, structure and diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney

David Keith

Keith, David, (NSW National Parks and Wildlife Service, PO Box 1967, Hurstville NSW Australia 2220) 1994. Floristics, structure and diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney. Cunninghamia 3(3): 543–594. Fifteen plant communities were described and mapped at 1:25 000 scale in O'Hares Creek catchment. Cluster analysis and ordination were used to elucidate relationships between the vegetation and environmental variables. Three forest communities and one scrub community occurred on relatively fertile, well-drained soils; three woodland and three heath communities occurred on less fertile, well-drained to damp soils; and five swamp communities occurred on periodically waterlogged soils of varying fertility. Floristic composition and vegetation structure were related to a complex of factors reflecting soil fertility and moisture status, as well as a regional rainfall gradient related to elevation and distance from the coast.

Of 510 vascular plant taxa recorded, 17 are listed as rare or threatened nationally and a further 24 are of regional conservation significance. The exotic flora is small (34 taxa recorded) and locally restricted to disturbed sites. While most of the plant communities have analogues in other parts of the Sydney sandstone area, their floristic composition is particular to the Nepean ramp, an area not well sampled by existing conservation reserves. The O'Hares Creek area and other water catchment areas, which cover much of the Nepean ramp, are therefore an important augmentation to the formal reserve system.

Introduction

Emerging from pastoral country around Appin on 21 October 1818, Allan Cunningham, then King's Botanist, remarked, 'we arrived at once upon an entire change of country, of a rugged sandstony character, alternated by extensive tracts of spongy bogs' (Lee 1925). Cunningham's sketch aptly captures a landscape that subsequently attracted numerous botanists to the area. Among them were Joseph Henry Maiden, a former Director of the Royal Botanic Gardens in the early 1900s, and Consett Davis, one of Australia's early students in classical plant ecology. Their publications, notes and collections contributed to early knowledge of the flora.

In recent years, the O'Hares Creek catchment is increasingly the focus of competing land-uses including nature conservation, mining, military activities, water supply and recreation. Conflicts between these land-uses are unlikely to be resolved rationally without a more thorough inventory of the biota than that provided by early work. This information, together with an evaluation of the regional significance of the biota, is required as a basis for ongoing management and conservation planning in the expanding southern Sydney–Wollongong–Campbelltown region.

This paper aims to describe the floristics, structure, diversity and habitat of plant communities, map their distribution, identify major environmental factors influencing vegetation patterns and evaluate the regional conservation significance of vegetation in the O'Hares Creek catchment.

Study area

The O'Hares Creek catchment, an area of 9 000 ha, is centred on latitude $34^{\circ} 14' S$ and longitude $150^{\circ} 52' E$, 45 km south-west of Sydney centre (Figure 1). The area comprises part of the Nepean Ramp, which is in turn, part of the Sydney Basin. The 'ramp' is a dissected plateau dipping gently north-west away from the Illawarra escarpment toward the Cumberland Plain. The major watercourses, O'Hares and Stokes Creeks, both flow from elevated, low-relief terrain in the south-east to more dissected terrain in the north-west. Elevation varies from 100 to 450 m above sea level.

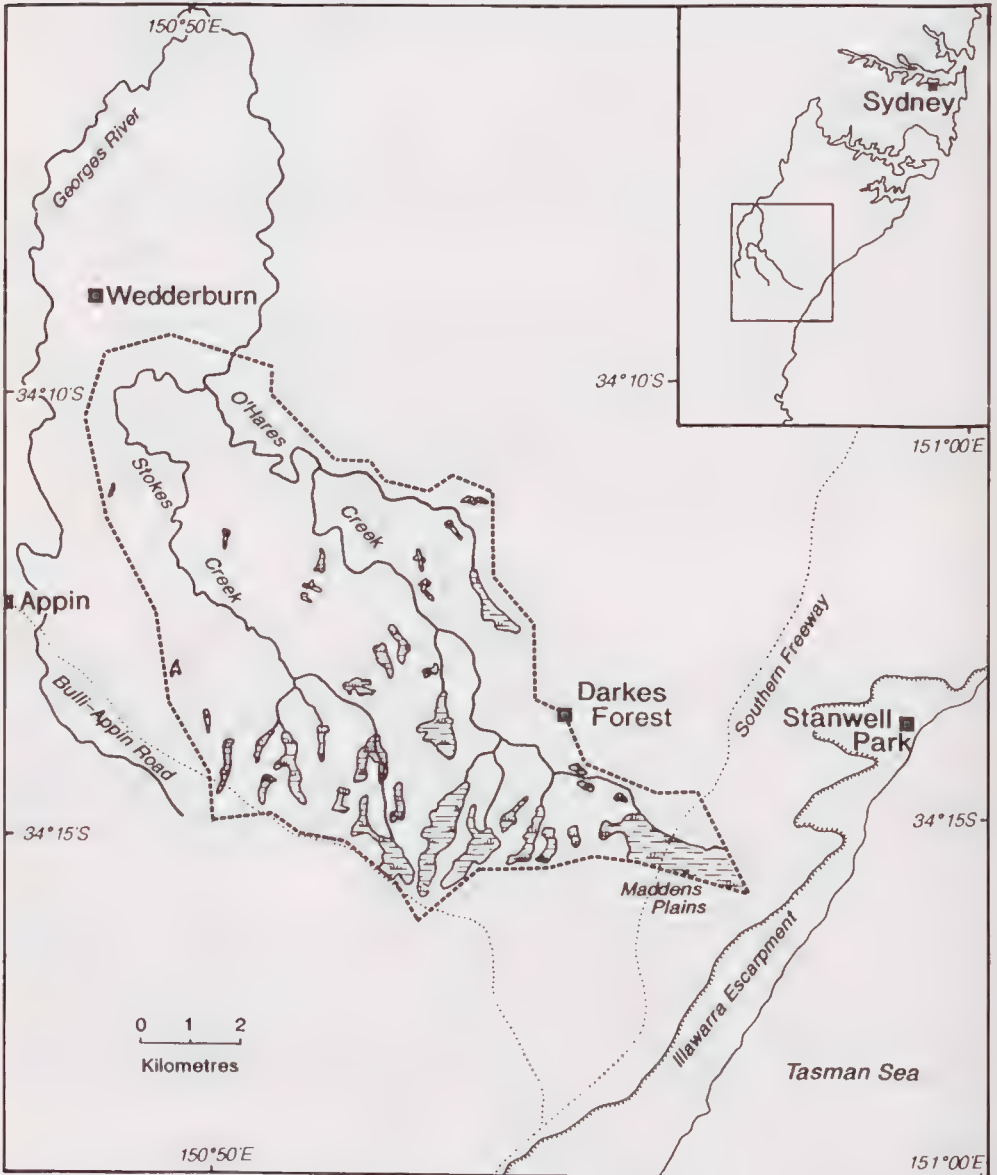


Figure 1. Location of O'Hares Creek catchment (from Keith & Myerscough 1993).

The Triassic Hawkesbury Sandstone Formation, the major geological unit of the plateau, is composed primarily of quartzose sandstone, but also includes lensoidal shale strata that outcrop in the eastern part of the catchment (Bowman et al. 1986). Thick ironstone mantles are present in some areas and may be the remnants of heavily weathered shale lenses (Sherwin et al. 1986). Deposits of swamp alluvium have accumulated in low-relief headwater valleys on the plateau (Young 1986a). The Hawkesbury Sandstone is underlain by the Triassic Narrabeen Group and the Permian Illawarra Coal Measures, respectively, which are exposed on the Illawarra escarpment. The Triassic Wianamatta Group overlies the Hawkesbury Formation and outcrops on the Cumberland Plain to the west.

The local climate is dominated by the influence of the Illawarra escarpment and the close proximity of the sea. There is a marked gradient in mean annual rainfall and seasonality from 1550 mm at Maddens Plains in the east to 850 mm at Wedderburn on the western edge of the catchment. An average annual evaporation rate of 800 mm at nearby Cataract Dam suggests a considerable moisture surplus in the east (unpubl. data, Bureau of Meteorology). At Maddens Plains, the wettest months are February and March, while September is the driest. Wedderburn has no obvious seasonal trend in rainfall. Rainfall also varies considerably from year to year, the range at Maddens Plains being 960–2550 mm. Temperatures vary from an average daily maximum of 25.9°C (January) to a minimum of 6.6°C (July) at Lucas Heights, 15 km north of the study area.

A major land-use on the Woronora Plateau is water catchment and supply, with the Sydney Water Board controlling five major dams. O'Hares Creek was set aside in the 1920s for this purpose but, unlike adjacent catchments, plans for impoundment of the creek were abandoned. The Water Board currently manages the area to maintain water quality by limiting development and restricting access. O'Hares Creek maintains a reliable supply of clean water to the Georges River, a major recreational waterway in southern Sydney. Coal is mined from the Bulli seam, 450–500 m below ground surface. Major coal processing plants and stock piles are located just to the west of the study area on the upper Georges River. Ventilation shafts and seismic survey lines have been constructed within the study area, resulting in localised disturbance. Other extractive industries within the catchment include small quarries for clay and sand, but these are now largely abandoned. O'Hares Creek catchment is used as a training area by the Australian Army as a supplement to Holsworthy Military Area which lies adjacent to the north. Orchards and hobby farms occupy shale-capped ridges at Darkes Forest and Wedderburn on the eastern and western watersheds of the catchment, respectively. These rural settlements were established in the late nineteenth century.

Methods

Remote sensing

Aerial photographs flown in May–July 1982 (Wollongong 1:16 000 Colour, Misc. 1320) were interpreted to categorise variation in vegetation structure across the catchment. The following structural types were mapped onto a 1:25 000 scale topographic map base: forest (single-stemmed trees ≥ 5 m tall and $\geq 20\%$ cover); woodland (single-stemmed trees ≥ 5 m tall and $< 20\%$ cover); mallee (multi-stemmed trees); heath (shrubs < 5 m tall).

Sampling strategy and data collection

Samples were stratified among categories of parent material, topography and vegetation structure (Table 1). Only eleven of 32 possible combinations of parent material, topography and structure were represented within the study area. Three of these sampling categories (forest on shale slopes, forest on sandstone plateau tops and heath on ironstone plateau tops) had very restricted occurrence and could only be allocated a small number of samples. The remaining eight categories were allocated at least four samples or more, depending on their geographic extent.

For all sampling categories except plateau alluvium dominated by shrubs, vegetation was sampled in 20 x 20 m quadrats, a standard size used by the National Parks and Wildlife Service and the National Herbarium in surveys of the coast and tablelands of New South Wales (e.g. Keith & Sanders 1990). All vascular plant species were allocated cover-abundance estimates on the Braun-Blanquet scale (Poore 1955). Height and projective foliage cover were estimated for tall tree, small tree, shrub and ground-cover strata whenever present. Aspect, slope, parent material type and exposed rock (% cover) were recorded and scores were estimated for soil texture (clay/clay-loam/loam/sandy-loam/sand), drainage (waterlogged/damp/moist/dry) and depth (skeletal/shallow/deep). Disturbance history was recorded if evident. Soil samples

Table 1. Stratification of 56 quadrats among parent material (Shale, Sandstone, Ironstone, Alluvium), topography (SI - slopes and gullies, PI - plateau) and vegetation structure (of dominant stratum).

- indicates combinations of parent material, topography and structure that do not exist within the study area.

* indicates 60 transect samples as described in Keith & Myerscough (1993).

Parent Material:	Shale		Sandstone		Ironstone		Alluvium	
Topography:	SI	PI	SI	PI	SI	PI	SI	PI
Structure:								
forest	1	2,3, 4,5, 6,7, 8	18,23, 24,25, 26,27, 28,29, 30,31, 32,33, 34,35, 36	9,10, 11	-	-	-	-
woodland	-	-	-	37,38, 39,40, 41,42, 43	-	12,13, 14,15, 44,45, 46	-	-
mallee	-	-	-	47,48, 49,50, 51,52	-	-	-	-
heath	-	-	-	53,54, 55,56	-	16,17 21,22	19,20, *	

were collected for chemical analysis from selected sites. Soils were analysed for exchangeable cations, pH and electrical conductivity (methods in Keith 1991).

Plateau alluvium (upland swamps) supported a fine-scale mosaic of wet heath that varied greatly in floristics, structure and soil characteristics over short distances. This variation could not be sampled satisfactorily by 20 x 20 m quadrats and was the subject of a related study (Keith & Myerscough 1993), in which 60 belt transects were stratified by categories of soil moisture and shrub dominance. Each transect consisted of sixty 0.5 m x 0.5 m quadrats, in which the presence of each vascular plant species was scored and summed over the whole transect. Structural and environmental data were gathered in a manner similar to the other sampling categories. Data were archived in a data base and geographic information system held by the NSW National Parks and Wildlife Service.

Data analysis

Matrices of dissimilarity between samples were calculated using the Kulczynski and Bray-Curtis association measures. These measures are 'non-linear' — species are weighted more highly in the calculation of similarity between two sites when they have higher abundances — and robust to variations in the response curves of species to environmental gradients (Faith et al. 1987). Each measure was applied both to raw data and data standardised by adjusting species to equal maxima, giving a total of four association matrices.

Cluster analysis was carried out using an unweighted pair-group arithmetic averaging procedure (UPGMA) with $\beta = -0.1$ to achieve space conserving behaviour (i.e. relationships between groups stay the same as clustering proceeds, Lance & Williams 1967). Belbin & McDonald (1993) found this strategy was more likely to retrieve natural clusters than two-way indicator species analysis (TWINSPAN, Hill 1978). Classifications based on the four association matrices were compared using homogeneity analysis (Bedward et al. 1992). The classification with the most homogeneous groups was interpreted by attempting to match floristic groups with the sampling categories in Table 1.

Floristic groups were mapped using their correspondence with the sampling categories which were based on mappable features of parent material, topography and vegetation structure. Additional aerial photograph interpretation and field reconnaissance were undertaken to refine vegetation boundaries, particularly on plateau alluvium. Map boundaries were digitised and exported as a postscript file from the geographic information system into desktop publishing software (Aldus Pagemaker) for preparation of the layout and legend. The map was printed directly from this system without manual cartographic preparation.

Relationships between floristic composition and environmental variables were examined using global non-metric multidimensional scaling (NMDS), a method that is more robust to variations in species response to environmental gradients than alternative ordination techniques (Minchin 1987). NMDS maximises the rank-order agreement between values in the association matrix and inter-point distances in ordination space of a specified number of dimensions. Ordinations were fitted from 10 random starting configurations in each of 2, 3 and 4 dimensions. For each number of dimensions, the solution with the lowest stress (i.e. best rank order agreement with the association matrix) was selected for analysis of environmental and structural data.

Nine environmental variables (slope, aspect, elevation, distance from coast, parent material, soil texture, soil moisture, soil depth and rock cover) and six structural

variables (height and cover for each of tree, shrub and ground strata) were standardised to a range of 0–1. The four categories of parent material were arranged in a sequence that reflected their relative nutrient status as indicated by the soil analyses (shale-alluvium-ironstone-sandstone). Aspect was coded as an index that reflected a sequence of increasing exposure (1: 120–210°; 2: 30–120° and 210–300°; 3: 0–30° and 300–360°). A vector for each variable was fitted to each of the three ordinations. Correlations between the vectors (indicating floristic composition) and their respective environmental and structural variables were tested using a Monte Carlo procedure (Minchin 1991).

The regional conservation significance of the vegetation was evaluated by: compiling a list of rare, threatened or biogeographically significant plant species; comparing levels of species richness with that in other areas; and attempting a comparison with vegetation elsewhere on Sydney sandstone using data from previous surveys and Pidgeon's (1941) regional classification.

Results

Native and introduced flora

Five hundred and ten vascular plant taxa were recorded in the O'Hares Creek catchment (list on reverse side of map). Of these, 382 were recorded in the 20 x 20 m quadrats, 165 were recorded in the swamp transects and 452 were recorded in either. Major plant families include Fabaceae (55 taxa), Myrtaceae (53), Proteaceae (44) and Cyperaceae (39).

A number of informal taxa were recognised where morphotypes or ecotypes could be distinguished repeatedly in the field. These include two forms of *Hakea dactyloides* (one lignotuberous with broad leaves and large fruits, the other single-stemmed with narrower leaves and smaller fruits, Hovenden 1989), two forms of *H. teretifolia* (one multi-stemmed up to 1.5 m tall, the other single-stemmed up to 5 m tall), two forms of *Lepidosperma viscidum* (one with colourless resin and narrow biconvex leaves, the other with red resin and broader flat leaves), two forms of *Leptospermum trinervium* (one with broad leaves, the other with narrower leaves, Krauss 1994), two forms of *Pultenaea elliptica* (one with red flowers and a short growth form, the other with yellow flowers and a tall growth form) and two forms of *Xanthosia pilosa* (one with densely hairy entire dentate leaves, the other with sparsely hairy narrow lobed leaves).

Seventeen taxa are listed as rare or threatened in Australia (Briggs & Leigh 1988, Table 2), some of which have distributions that are essentially restricted to the Nepean ramp. An additional 17 taxa are uncommon either generally or in the Sydney region, three taxa are represented by atypically coastal populations, including one with a population disjunct from other occurrences of the species. Eleven taxa reach the southern limit of their known distribution in the O'Hares Creek catchment.

Fifty non-indigenous taxa, mainly in the families Asteraceae, Fabaceae and Poaceae, were recorded within the study area (reverse side of map). Sixteen of these are native to Australia, but were considered unlikely to be indigenous to part or all of the study area. Introduced taxa were largely confined to disturbed areas, including abandoned quarries, the interface between farmland and bushland, and along major roads and tracks. Weeds were most abundant at sites exposed to heavy vehicular traffic (e.g. along Bulli–Appin Road, North Cliff mine access road, Lysaghts Road) and/or nutrient-enriched runoff from developed sites such as farmland, mine sites and major

Table 2. Vascular plant taxa of conservation significance in the O'Hares Creek catchment

Significance codes in upper case follow Briggs & Leigh (1988): 2- geographic range < 100 km; 3- geographic range >100 km; V- vulnerable; R -rare; K- poorly known but may be rare or threatened; C- represented within a conservation reserve (a- >1000 plants, i- < 1000 plants, -unknown number). Significance codes in lower case: cl- coastal locality of typically inland taxon; dp- disjunct population; sl- southern limit of distribution; uc- uncommon; ucs- uncommon in Sydney region. Refer to Appendix 1 for explanation of community abbreviations.

Taxon	Significance	Community/Distribution
<i>Acacia bynoeana</i>	3VC-	SW & RH south of Wedderburn. Northern Sydney-Berrima.
<i>Acacia stricta</i>	ucs	SF near Darkes Forest. Coast & tablelands Qld-Tas.
<i>Allocasuarina nana</i>	cl	MH north of O'Hares Ck. Mainly tablelands Blue Mtns-East Gippsland.
<i>Allocasuarina paludosa</i>	ucs	RH scattered in eastern part of catchment. Northern Sydney-Tas.
<i>Angophora hispida</i>	sl	IH & MH in centre of catchment. Gosford-O'Hares Ck.
<i>Banksia cunninghamii</i>	cl	EGF scattered along O'Hares Ck gully. Scattered mainly along NSW tablelands and coastal East Gippsland.
<i>Blandfordia cunninghamii</i>	3RC-	WGF along Pheasant Ck, Wedderburn. Blue Mtns & Nepean ramp.
<i>Blechnum ambiguum</i>	uc	EGF restricted to sandstone overhangs throughout gullies. Mainly Sydney sandstone, also Qld.
<i>Boronia serrulata</i>	uc,sl	SW near Northcliff mine. Wondabyne-Manly & Loftus-O'Hares. Uncommon south of Sydney.
<i>Callitris endlicheri</i>	cl,dp	RPH south of Darkes Forest. Widespread in dry and semi-arid woodlands on the tablelands, western slopes and plains.
<i>Corybas fordhamii</i>	ucs	CH, SL & RH scattered in eastern part of catchment. Scattered on coast and tablelands.
<i>Darwinia diminuta</i>	3RCi,sl	MH near Northcliff mine. Manly-Ingleside & Loftus-O'Hares Ck.
<i>Darwinia grandiflora</i>	2RC-	WH & RH scattered in eastern part of catchment. Endemic to Nepean ramp.
<i>Doryanthes excelsa</i>	sl	SF & EGF throughout eastern part of catchment. Scattered localities from far north coast to Bulli-Appin Rd.
<i>Epacris coriacea</i>	3RC-	EGF near confluence of O'Hares & Cobbong Cks. O'Hares Ck-Macquarie Pass & Rhylstone.
<i>Eriachne glabrata</i>	sl	RH scattered in eastern part of catchment. Along coast Qld-O'Hares Ck.
<i>Eucalyptus apiculata</i>	2R	RH, MH & RPH in eastern part of catchment. Berrima, Nepean ramp & Linden. Intergrades with <i>E. stricta</i> .
<i>Eucalyptus ligustrina</i>	uc	SW west of Darkes Forest. Nepean ramp, Blue Mtns & Gibraltar Range.

<i>Eucalyptus luehmanniana</i>	2RCa,sl	MH scattered in eastern part of catchment. Gosford-O'Hares Ck.
<i>Eucalyptus multicaulis</i>	uc	SW & WGF mainly near Wedderburn. Hornsby Plateau, Nepean ramp, Blue Mtns, Jervis Bay & Budawang Range.
<i>Eucalyptus squamosa</i>	uc	WGF near Wedderburn, Hornsby Plateau & Nepean ramp.
<i>Gonocarpus salsoloides</i>	3RCa,sl	CH & SL scattered in eastern part of catchment. Port Macquarie-O'Hares Ck.
<i>Grevillea diffusa</i> var. <i>diffusa</i>	uc	SW & EGF throughout catchment. Menai-Cordeaux Dam. Form restricted to Bulli-Appin.
<i>Grevillea longifolia</i>	2RC-	EGF along O'Hares & Stokes Cks. Waterfall-Cataract Dam & Lawson-Springwood.
<i>Hibbertia nitida</i>	2RC-	EGF along O'Hares & Stokes Cks. Thornleigh-Manly & Oatley-Nepean Dam.
<i>Leucopogon amplexicaulis</i>	uc	EGF along O'Hares & Stokes Cks. Gosford-Pigeon House Mtn.
<i>Leucopogon exolasius</i>	2VC-,sl	EGF scattered along O'Hares & Stokes Cks. Woronora-Georges Rivers & Grose River.
<i>Lomandra fluviatilis</i>	3RC-	RS along O'Hares & Stokes Cks. Colo River-Cataract Dam.
<i>Melaleuca deanei</i>	3RC-	SW at Wedderburn. Hornsby Plateau & Nepean ramp.
<i>Melaleuca squamea</i>	ucs	CH scattered in eastern part of catchment. Scattered along tablelands & coast northern NSW-Tasmania.
<i>Melichrus urceolatus</i>	ucs	SW in western part of catchment. Widespread on coast, tablelands, slopes & plains of NSW, Qld & Vic, but only 2 localities in Sydney region.
<i>Monotoca ledifolia</i>	3RC-	RPH scattered in south-eastern part of catchment. Blue Mtns & Nepean ramp.
<i>Persoonia mollis</i> subsp. <i>nectans</i>	uc	EGF east of Darkes Forest. Restricted to Nepean ramp.
<i>Prasophyllum nublingii</i>	2KC-,sl	SW in southern part of catchment. Royal NP-O'Hares Ck.
<i>Pseudanthus orientalis</i>	ucs,sl	BT & MH scattered in eastern part of catchment. Qld-O'Hares Ck, usually on coastal sand dunes.
<i>Pultenaea aristata</i>	2VC-	BT, RH & MH mainly in eastern part of catchment. Helensburgh-Mt Kiera & Budawang Range.
<i>Pultenaea divaricata</i>	ucs	TT & CH scattered in larger swamps. Blue Mtns-Corang.
<i>Pultenaea hispidula</i>	ucs	SF scattered in eastern part of catchment. Hornsby Plateau-East Gippsland.
<i>Tetratheca neglecta</i>	3RC-	SW, IW & MH throughout catchment. Sutherland-Robertson.
<i>Tetratheca shiressii</i>	sl	SW near Northcliff mine. Watagan Mtns-Hawkesbury River & Sutherland-O'Hares Ck
<i>Thelymitra circumsepta</i>	ucs	RH & IW in eastern part of catchment. Northern NSW coast-East Gippsland.

roads. The most abundant introduced species along roads was *Andropogon virginicus*. Localised infestations of *Ageratina adenophora* occur south of Darkes Forest coal mine, where treated sewerage effluent was sprayed upon native vegetation. Native vegetation away from developed sites is remarkably free of weeds. Only three out of the 56 samples included introduced taxa. The three taxa recorded (*Hypochoeris radicata*, *Conyza albida* and *Rubus ?discolor*) had cover-abundance scores of 1 (uncommon and < 5% cover). Watercourses were apparently free of weeds, with no introduced taxa recorded in any of the riparian samples.

Classification and mapping

Classifications based on raw data grouped samples into more homogeneous groups than those based on standardised data (Figure 2). The two classifications based on raw data were similar, but the Kulczynski classification (Figure 3) corresponded more closely with the sampling categories (Table 1) than the Bray-Curtis classification.

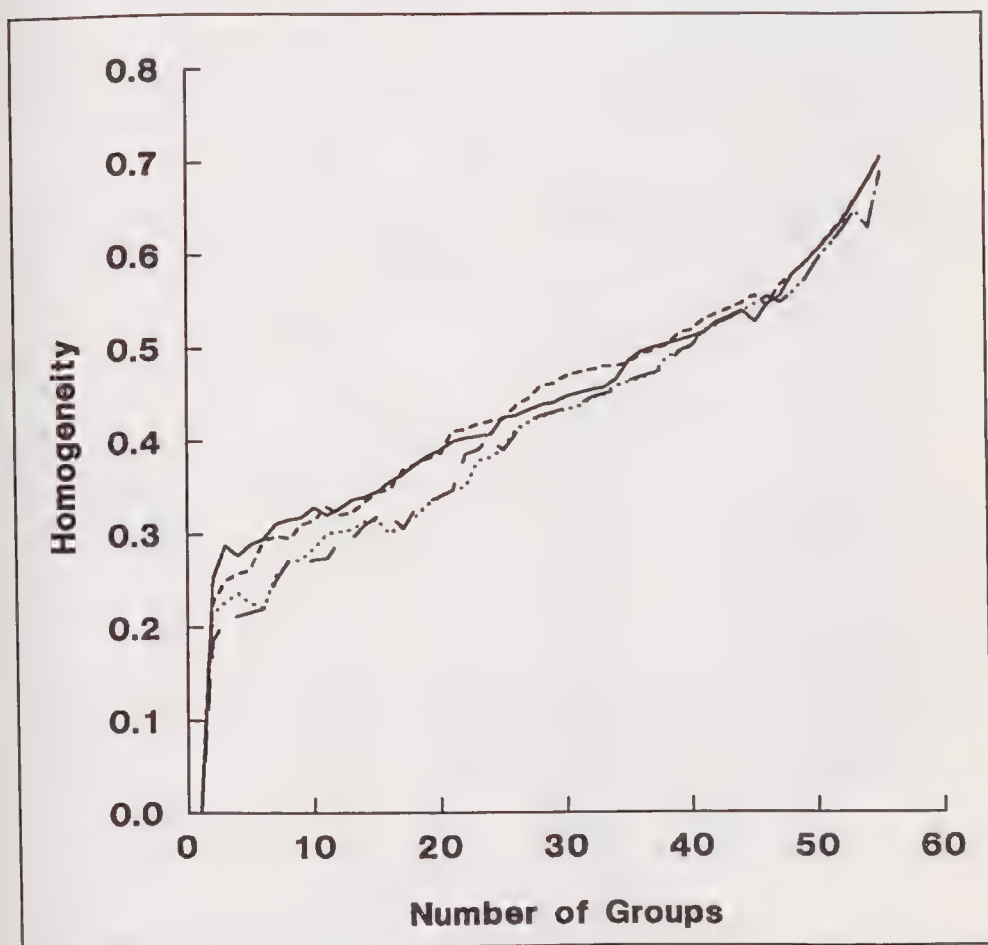


Figure 2. Homogeneity curves for site classifications based on raw data and Kulczynski coefficient (-----), raw data and Bray-Curtis coefficient (—), standardised Kulczynski coefficient (....) and standardised Bray-Curtis coefficient (- - -).

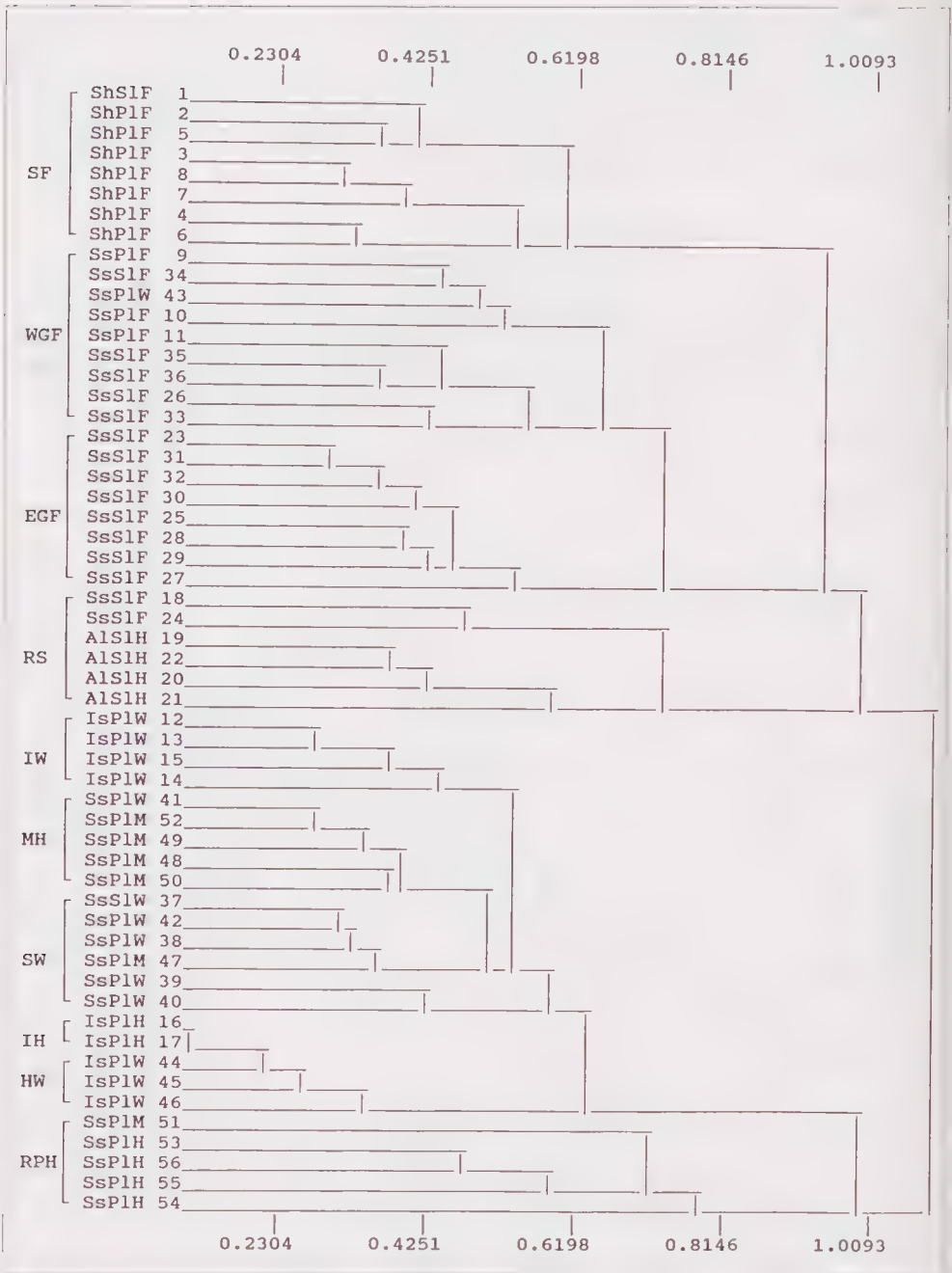


Figure 3. Classification of non-swamp sites based on raw data and Kulczynski coefficient with UPGMA clustering. See Appendix 1 or vegetation map for abbreviations of plant community names. Sample labels indicate sampling cell to which sample belongs (Table 1): Sh - shale; Ss - sandstone; Is - ironstone; Al - creek alluvium; Pl - plateau top; Sl - slopes and gullies; F - forest; W - woodland; M - mallee; H - heath.

Five major groups can be identified from Figure 2 and correspond to groups of sampling categories defined in Table 1: forest on shale (eight sites); forest on sandstone gully slopes (17 sites); scrub on alluvium in gullies (six sites); woodland, mallee and heath on the sandstone/ironstone plateau (20 sites); and heath on the sandstone plateau (five sites).

The first major group was made up of seven forested shale sites on the plateau and one on gully slopes and was recognised as a single community, 'Shale Forest'. The second major group included 13 forested sites on sandstone gully slopes and four on the plateau. It was split into two communities (Figure 3): one confined to the western side of the catchment, 'Western Gully Forest'; the other confined to the eastern side of the catchment, 'Eastern Gully Forest'. The third major group included four heath sites on alluvium in gullies and two forested sites in sandstone gullies and was recognised as a single community, 'Riparian Scrub'.

The fourth major group was a complex of sites from five different sampling categories (Figure 3). Within this complex, three woodland groups could be distinguished from one another on floristic grounds: 'Ironstone Woodland' (sites 12, 13, 14, 15); 'Sandstone Woodland' (sites 37, 42, 38, 47, 39, 40); and 'Heath Woodland' (sites 44, 45, 46). Map boundaries were determined by field traverse because their structure and parent materials were difficult to separate on aerial photographs. A group of mallee sites (41, 52, 49, 48, 50) was closely related in floristics to Sandstone Woodland, but was distinct in structural characteristics and mapped as 'Mallee Heath'.

Table 3. Correlations of environmental and structural variables with floristic ordination vectors in 2, 3 and 4 dimensions

	Number of Ordination Dimensions		
	4	3	2
Slope	0.6528***	0.5367***	0.3576*
Aspect Index	0.3482ns	0.2204ns	0.1737ns
Elevation	0.6811***	0.6756***	0.3524*
Distance from Coast	0.7169***	0.7056***	0.0439ns
Parent Material	0.8329***	0.6602***	0.5888***
Soil Depth	0.8343***	0.8365***	0.7890***
Soil Quartz	0.7274***	0.6937***	0.6292***
Soil Moisture	0.8108***	0.7422***	0.6516***
Rock cover	0.7222***	0.7208***	0.6763***
Tree height	0.8888***	0.8296***	0.7757***
Tree cover	0.8173***	0.8100***	0.7913***
Shrub height	0.7473***	0.7401***	0.7087***
Shrub cover	0.4474*	0.4422*	0.3901*
Ground height	0.5432***	0.5257***	0.4377***
Ground cover	0.7252***	0.6455***	0.4364***

*** = significant at P < 0.001
* = significant at P < 0.05
ns = not significant P > 0.05

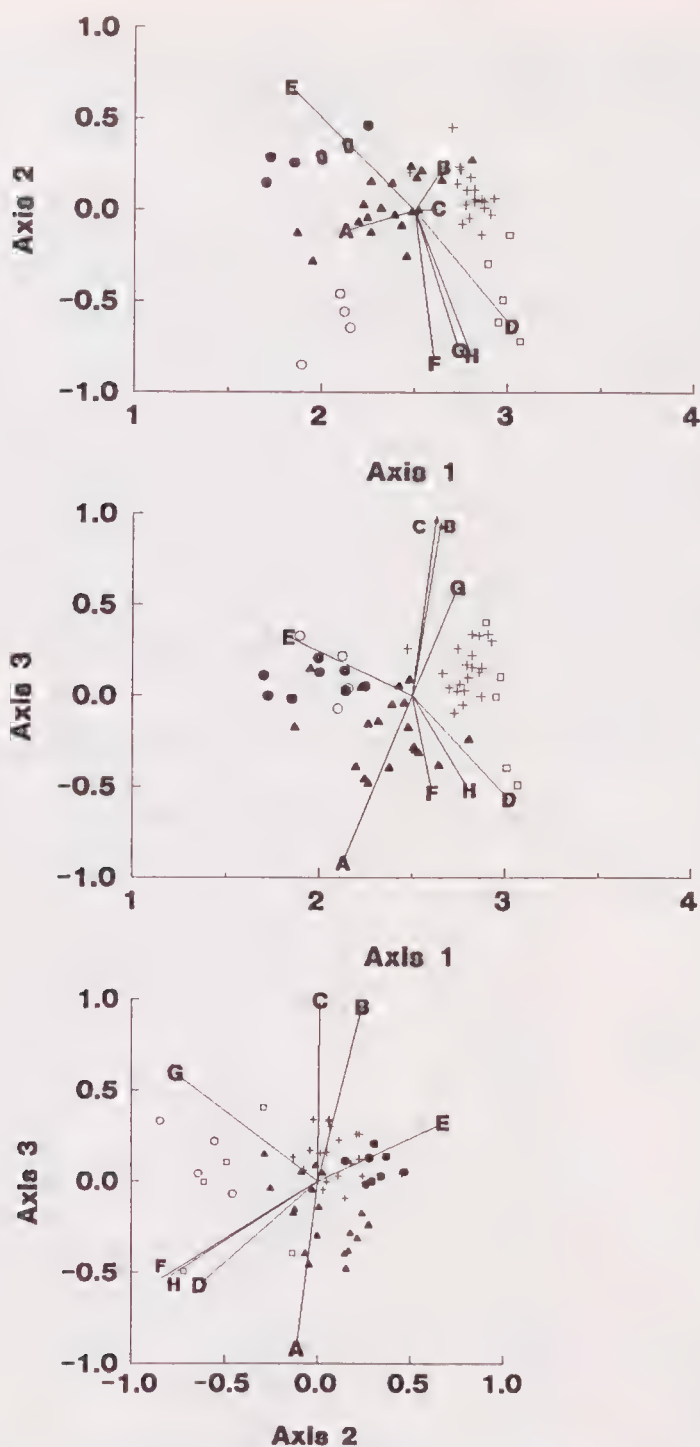


Figure 4. Three-dimensional ordination of non-swamp sites showing vectors significantly correlated with environmental variables: A - slope; B - elevation; C - distance from coast; D - parent material; E - soil depth; F - soil quartz; G - soil moisture; H - rock cover. Symbols show groups of plant communities: - SF; - - EGF and WGF; o - RS; [] - RPH; + - all other communities.

Two heath sites on ironstone (16, 17) had similar floristic composition to the Heath Woodland sites (44, 45, 46) but, primarily because of their different structure, were mapped separately as 'Ironstone Heath'. The fifth major group in Figure 2 was recognised as a single community, 'Rock Pavement Heath'.

Classification of upland swamp (heath on plateau alluvium) communities was based on the analysis by Keith & Myerscough (1993) which recognised five communities: Ti-Tree Thicket; Cyperoid Heath; Sedgeland; Restioid Heath; and Banksia Thicket. However, only two of these could be mapped separately using aerial photopattern (Ti-tree Thicket and Banksia Thicket), so the remaining three were included in a single map unit, 'Sedgeland-Heath Complex'.

The vegetation map shows the distribution of plant communities described in Appendixes 1 and 2.

Environmental and structural relationships with floristic composition and richness

The 4-dimensional ordination had a lower level of stress (0.0777), than ordinations in three (0.0992) and two (0.1587) dimensions. Vectors fitted to the 4-dimensional ordination were more highly correlated with environmental and structural variables than those fitted in three and two dimensions, the latter giving a poor representation of floristic relationships, particularly with slope and elevation (Table 3). However, the 3-dimensional ordination (Figure 3) represented all significant relationships in fewest dimensions.

Slope, elevation, distance from coast, parent material, soil depth, quartz and moisture, rock cover, tree height and cover, shrub height, ground stratum height and cover were all highly correlated with floristic composition, as indicated by the 3- and 4-dimensional ordinations ($P < 0.001$, Table 3). Shrub cover was marginally correlated with floristic composition ($P < 0.05$). There was no correlation between floristics and aspect ($P > 0.05$). Soil depth, soil quartz, rock cover and parent material were closely related ($P < 0.001$, Figure 4). Height and tree cover were highly correlated with one another and with soil moisture ($P < 0.001$). There were also significant correlations between the tree stratum and soil depth, slope and shrub cover (Figure 4). Elevation and distance from the coast were inversely correlated ($P < 0.001$), but independent of other variables. Aspect was not correlated with any of the other environmental or structural variables ($P > 0.05$, Figure 4).

Plant communities showed high fidelity with one type of parent material, and there were corresponding differences between communities in soil properties (Table 4). The five swamp communities occupied soils that were deep, fine-textured, water-logged and without exposed rock. Shale Forest also occupied deep fine-textured soils, but these were well drained and their fine texture was due to a high proportion of mineral clay and silt, rather than fine organic particles as was the case in swamp soils. Rock Pavement Heath was distinguished from remaining communities by its skeletal soils and extensive outcrops of rock. Communities on sandstone had the highest levels of soil quartz and exposed rock. Forest and woodland communities occupied well-drained soils, while heath and swamp communities occurred on soils whose drainage is impeded to varying degrees. Soils supporting Ironstone Woodland, Sandstone Woodland, Mallee Heath, Ti-tree Thicket and Shale Forest had higher pH than other communities. Shale Forest, Eastern Gully Forest, Ironstone Woodland, Sandstone Woodland and Mallee Heath form a sequence of decreasing soil fertility, as indicated by conductivity and exchangeable cations (Table 4). Among

Table 4. Soil characteristics of plant communities

Data for soil depth, quartz and moisture are medians with ranges in parentheses for scales of 1–5, 1–4 and 1–3, respectively. All other data are means with standard errors in parentheses. Parent materials: Sh– shale; Ss– sandstone; Al– creek alluvium; Is– ironstone; Sw– swamp alluvium. Rock cover in %, electrical conductivity in $\text{mS}\cdot\text{cm}^{-1}$, exchangeable cations in milliequivalents/100g air-dried soil.

Community	Parent Material	Soil Depth	Soil Quartz	Soil Moisture	Rock Cover	pH	Elec. Cond.	Exch. Na	Exch. K	Exch. Ca	Exch. Mg	Exch. Al	Total Ex.
Shale Forest	Sh	5	1	1	1	4.3	0.062	0.16	0.23	2.12	1.39	1.72	5.62
		(3–5)	(1–3)	(1–2)	(1)	(0.3)	(0.012)	(0.05)	(0.10)	(1.29)	(0.39)	(0.65)	(2.28)
Western Gully Forest	Ss	3	3	1	5	–	–	–	–	–	–	–	–
		(2–4)	(2–4)	(1–1)	(2)								
Eastern Gully Forest	Ss	3	4	1	11	3.6	0.050	0.07	0.14	0.80	0.88	0.81	2.70
		(3–3)	(3–4)	(1–2)	(2)	(0.1)	(0.006)	(0.02)	(0.02)	(0.03)	(0.36)	(0.15)	(0.56)
Riparian Scrub	Al	3	4	3	11	–	–	–	–	–	–	–	–
		(3–4)	(3–4)	(1–3)	(2)								
Ironstone Woodland	Is	3	2	1	1	4.5	0.038	0.06	0.05	0.52	0.36	0.72	1.70
		(3–3)	(2–3)	(1–2)	(1)	(0.1)	(0.003)	(0.01)	(0)	(0.11)	(0.14)	(0.22)	(0.48)
Sandstone Woodland	Ss	3	3	1	3	4.4	0.027	0.05	0.06	0.32	0.28	0.28	0.99
		(3–3)	(2–4)	(1–2)	(2)	(0.1)	(0.002)	(0.01)	(0.01)	(0.08)	(0.07)	(0.11)	(0.16)

Ironstone Heath	Is	3	1	3	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		(3-3)	(1-1)	(3-3)	(0)														
Heath Woodland	Is	3	2	2	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		(3-3)	(2-2)	(1-3)	(0)														
Rock Pavement Heath	Ss	1	4	2	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		(1-1)	(4-4)	(2-3)	(9)														
Banksia Thicket	Sw/Ss	4	2	3	0	3.8	0.059	0.08	0.04	0.13	0.28	1.75	2.30						
		(3-4)	(2-3)	(3-3)	(0)	(0.1)	(0.007)	(0.01)	(0.01)	(0.05)	(0.04)	(0.40)	(0.45)						
Restioid Heath	Sw	4	2	3	0	3.9	0.043	0.05	0.03	<0.05	0.11	0.67	0.83						
		(3-4)	(1-3)	(3-3)	(0)	(0.1)	(0.004)	(0.01)	(0.01)	(-)	(0.04)	(0.18)	(0.24)						
Sedgeland	Sw	4	1	3	0	4.1	0.049	0.05	0.04	<0.05	0.12	0.68	0.85						
		(3-4)	(1-3)	(3-4)	(0)	(0.1)	(0.003)	(0.01)	(0.01)	(-)	(0.02)	(0.12)	(0.15)						
Cyperoid Heath	Sw	5	1	4	0	3.8	0.080	0.12	0.08	0.08	0.30	2.33	2.86						
		(4-5)	(1-3)	(3-4)	(0)	(0.1)	(0.012)	(0.02)	(0.01)	(0.03)	(0.04)	(0.45)	(0.54)						
Ti-tree Thicket	Sw	5	1	4	0	4.4	0.164	0.53	0.20	1.31	0.97	2.80	4.94						
		(5-5)	(1-2)	(4-4)	(0)	(0.2)	(0.013)	(0.20)	(0.03)	(0.74)	(0.41)	(0.57)	(1.00)						

the swamp communities, Ti-tree Thicket had the most fertile soils, Restioid Heath and Sedgeland the least fertile and Cyperoid Heath and Banksia Thicket were intermediate. Swamp soils had higher levels of Aluminium as a proportion of total exchangeable cations than soils supporting forest and woodland vegetation. Swamp soils had similar levels of total exchangeable cations and greater conductivity than those of forests and woodlands when considered on a dry-weight basis. However, if data in Table 4 could be corrected for variations in bulk density due to organic matter, overall fertility of swamp soils would be low to moderate, relative to soils supporting forests and woodlands.

Trees were tallest in Shale Forest and Eastern and Western Gully Forests, but had more cover in Shale Forest than the other two forest communities (Figure 6a). Mallee Heath had the shortest trees, but these were greater in cover than those of the three woodland communities. Trees were generally absent from Riparian Scrub, Ironstone Heath, Rock Pavement Heath and the five swamp communities. Shrubs were tallest and had least cover in Shale Forest and were tall with most cover in Banksia Thicket. The remaining communities had similar shrub strata, except that shrubs were taller in Riparian Scrub, Ti-tree Thicket and Eastern and Western Gully Forests (Figure 6b).

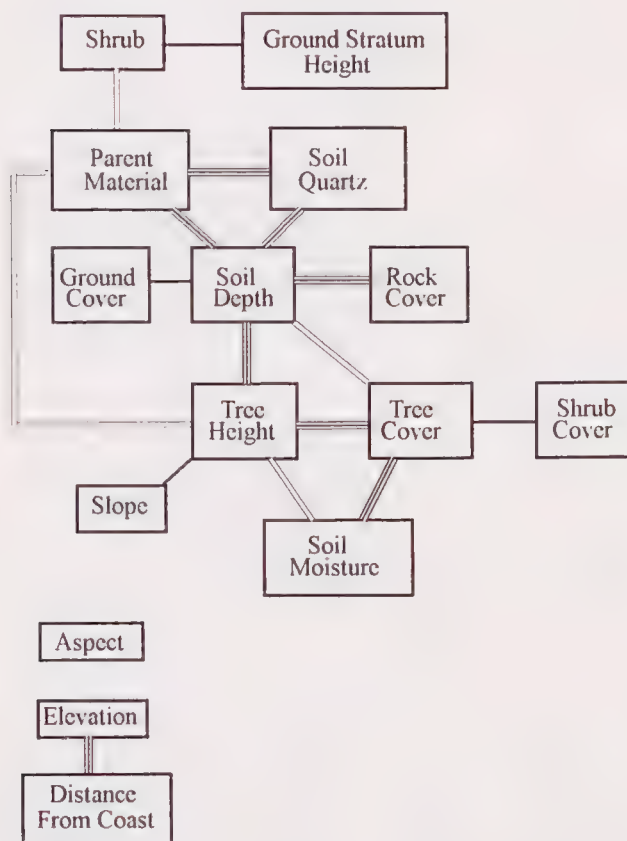


Figure 5. Correlations among environmental variables and structural characteristics of vegetation. Triple line $P < 0.001$; double line $P < 0.01$; single line $P < 0.05$.

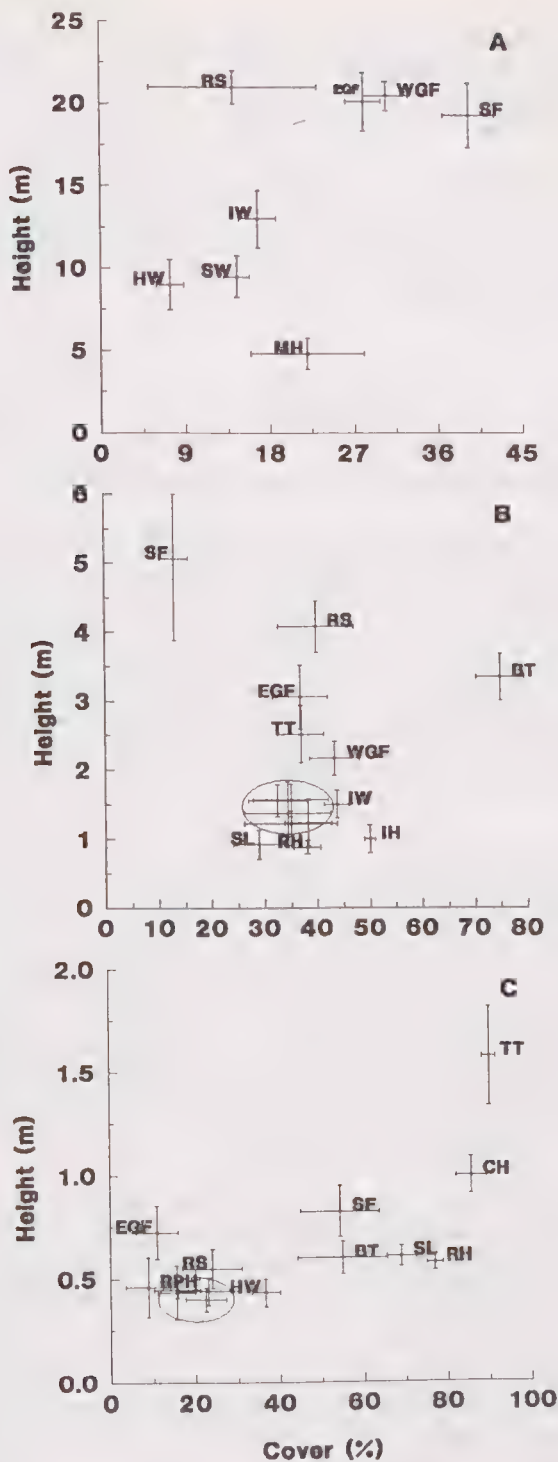


Figure 6. Mean height and cover of (a) tree strata, (b) shrub strata and (c) ground strata for each plant community. Refer to Appendix 1 or vegetation map for abbreviations of plant community names. Errors bars are standard errors of the mean. In (b) the ellipse contains unlabelled data points for SW, HW, MH, RPH & CH. In (c) the ellipse contains unlabelled data points for WGF, IW, SW, MH & IH.

The five swamp communities had a dense and tall groundcover, as did Shale Forest, though its composition was very different. The groundcover of Heath Woodland and Ironstone Heath was similar in composition to the swamp communities, though less dense. Rock Pavement Heath had the least ground cover (Figure 6c).

The most species-rich communities were Mallee Heath, Ironstone Heath and Heath Woodland (Table 5). Restioid Heath is similarly species rich, but caution is required when comparing richness between swamp and non-swamp communities because of the different scales at which they were recorded. Species Richness was lowest in Rock Pavement Heath and Ti-tree Thicket.

Discussion

Vegetation patterns and environmental relations

The major dichotomy in the dendrogram (Figure 3) distinguishes plant communities on shale, creek alluvium and sandstone gullies from those on sandstone and ironstone sites on the plateau. Upland swamps comprise a third major group of communities. The first group of communities is characterised by relatively fertile, well-drained soils, the second group occurs on soils of low fertility and free to moderate drainage, while the third group is restricted to waterlogged soils of varying fertility. Differences in soil chemistry, texture and moisture also delimit individual communities within these groups (Table 4). A suite of inter-related soil factors are highly correlated with overall trends in floristic composition (Table 3) and with aspects of vegetation structure (Figure 5).

The identification of soil fertility and moisture as determinants of plant community distribution is consistent with findings of earlier workers. Beadle (1954, 1962) and Clements (1983) demonstrated the role of soil nutrients, particularly phosphorus, in delimiting forest and woodland communities on Sydney shales and sandstones. Pidgeon (1938), Davis (1941) and Buchanan (1980) identified soil moisture as a factor influencing structure and composition, especially on sandstone. In the Darkes Forest-Maddens Plains-Sublime Point area, Davis (1941) demonstrated differences in the water-retaining capacity and organic content of soils between a *Eucalyptus piperita* association (cf. Shale Forest), an *E. sieberi* association (cf. Sandstone Woodland, Ironstone Woodland and Heath Woodland) and a *Gymnoschoenus sphaerocephalus* association (cf. Cyperoid Heath and Restioid Heath).

Within O'Hares Creek catchment, vegetation patterns attributable to variation in soil moisture may be thought of at local and regional scales. At a local level, the response of floristics and structure to changes in drainage due to parent material and landform over short distances is illustrated by the large number of map units present in a small area, particularly in the eastern part of the catchment where there are fine-scale mosaics including three woodland communities, three heath communities and five upland swamp communities. The rainfall gradient superimposes a regional trend on moisture availability due to the occurrence of certain plant communities and species. Such a trend is illustrated, for example, by the diminishing extent of upland swamps, the replacement of Eastern Gully Forest with Western Gully Forest and the correlation of overall floristic composition with decreasing elevation and increasing distance from the coast (Table 3). Burrough et al. (1977) identified similar regional trends in vegetation in relation to a rainfall gradient across the Budderoo Plateau, 50 km south of Darkes Forest.

Table 5. Species richness of plant communities

Community	mean	se	n	area (m ²)
O'Hares Creek catchment				
Shale Forest	41	2	8	400
Western Gully Forest	40	1	9	400
Eastern Gully Forest	57	4	8	400
Riparian Scrub	36	6	6	400
Ironstone Woodland	52	2	4	400
Sandstone Woodland	57	2	6	400
Mallee Heath	64	4	5	400
Ironstone Heath	62	0	2	400
Open Ironstone Woodland	66	3	3	400
Rock Pavement Heath	23	6	5	400
Banksia Thicket	40	2	7	15
Restioid Heath	55	2	15	15
Sedgeland	40	3	13	15
Cyperoid Heath	37	2	16	15
Ti-tree Thicket	24	2	9	15
Yengo National Park¹				
Dry forest (1)	44		11	400
(2)	47		6	400
(3)	45		15	400
Dry woodland (4)	37		43	400
Garrigal National Park²				
Dry forest (7)	42		2	400
Dry forest/woodland (10)	49		3	400
(12)	55		6	400
Dry woodland (13)	55		8	400
Yuraygir National Park³				
Wet/dry forest (5)	52	8	3	400
Dry forest (6)	30	2	10	400
(7)	40	2	3	400
(17)	42	3	3	400
Dry heath (35)	38	2	11	400
Wet heath (37)	30	1	11	400
(39)	26	2	18	400
South East Forests⁴				
Wet forest (91)	39	2		400
Dry forest (16)	39	2		400
(261)	30	2	17	400
(28)	33	3	11	400
Dry heath (33)	35	4	6	400
Upland swamp (40)	35	4	5	400

Sources: 1. Sanders et al. (1988); 2. Sherringham & Sanders (1993); 3. Griffith (1988); 4. Keith & Sanders (1990). Numbers in parentheses are community numbers used by respective authors.

Conservation

Representativeness of plant communities and species

O'Hares Creek catchment samples a small part of the extensive Sydney sandstone landscape. Sandstone Woodland and Eastern Gully Forest, collectively covering 64% of the catchment, typify a recurring pattern of woodland on ridges and forest in gullies that is widespread throughout the Sydney sandstone landscape (Pidgeon 1938). While a large proportion of this landscape is represented within reserves, the diversity and regional variability of its vegetation may not be fully appreciated.

Keith & Myerscough (1993) have drawn attention to the species richness of upland swamps in O'Hares Creek catchment, which is high relative to other shrub-dominated vegetation types around the world. Levels of species richness in dry sclerophyll forests, dry sclerophyll woodlands and heathlands at O'Hares Creek are higher than in comparable plant communities in other parts of coastal New South Wales (Table 5), exceed those in wet sclerophyll forests on the north and south coast (e.g. Binns & Chapman 1992, Keith & Sanders 1990) and are high relative to those in temperate forests and woodlands on other continents (e.g. Peet 1978).

Pidgeon (1941) noted that many species are restricted in their distribution to parts of the sandstone area, while others occur throughout. She divided the Sydney sandstone into regions that differ from one another physiographically, climatically and in the groups of vegetation types they support. Most of O'Hares Creek catchment samples the Nepean Ramp sub-region, but in the west it includes a southern outlier of the Macdonald region. Of six existing conservation reserves on the Nepean Ramp, two (Illawarra and Macquarie Pass National Parks) are located on the Illawarra Escarpment and sample extremely small areas of the sandstone plateau, and four (Royal, Heathcote, Garrawarra and Georges River NPs) are located on the northern edge of the plateau. The southern outlier of the Macdonald region is not represented in any reserves. Unlike the combined reserves to the north, O'Hares Creek samples a transition from the Coastal region to the Macdonald region (Pidgeon 1941) that also occurs over a longer and interrupted stretch of country to the north of Sydney.

Data gathered since Pidgeon's (1941) work allow further insight into the heterogeneity of Sydney sandstone vegetation by comparing the occurrence of selected taxa in analogous communities of different regions. The taxa selected for comparison were trees and widespread genera of understorey shrubs (*Grevillea*, *Leucopogon*, *Acacia* and *Pultenaea*). Analogies between plant communities in different part of Sydney were determined by identifying vegetation in similar habitats (i.e. sandstone gullies and ridges capped by Hawkesbury shale). In forest communities in sandstone gullies only four of 42 species (10%) were represented in more than seven of ten localities surveyed, whereas 27 species (64%) were recorded at three or less of the ten localities (Table 6a). Representation of species is even more localised in widely scattered, but locally restricted vegetation types, in which floristic similarities between stands may be limited by dispersal. In forests on shale lenses only five of 30 species (17%) were represented at more than three of five localities surveyed, whereas 22 species (73%) were represented at less than three of the five localities (Table 6b). Moreover, each of the five 'shale forests' includes species not known from any of the others.

Full assessment of the conservation status of Sydney sandstone vegetation requires quantitative analysis of more comprehensive data than that currently available. Nonetheless, these data emphasise the importance of conserving samples of vegetation types throughout their range, if the full diversity and variability of Sydney sandstone vegetation is to be conserved.

Table 6. Representation of selected taxa in analogous vegetation types at various localities on Sydney sandstone (X-dominant, x-other taxa)

a) **Forest in Sandstone Gullies.** Regions after Pidgion (1941): Cn- Coastal, Nepean Ramp sub-region; Ch- Coastal, Hornsby Plateau sub-region; Co- Coastal, Ourimbah sub-region; Mn- Macdonald north; Ms- Macdonald south; LBM- Lower Blue Mountains; UBM- Upper Blue Mountains. Localities: OHE- O'Hares Creek east (comm. EGF, this study); OHW -O'Hares Creek west (comm. WGF, this study); RNP- Royal NP (Keith unpubl. data); BBP- Bents Basin NP (comms. 8, 9 & 10, Benson et al. 1990); KAT- Katoomba area (comm. 9), Keith & Benson 1988); YNP- Yengo NP (comms. 1, 2 & 3, Sanders et al. 1988); DNP- Dharug NP (comm. C1, Clarke & Benson 1986); GNP- Garrigal NP (map unit 9, Sherringham & Sanders 1993); KCP- Ku-ring-gai Chase NP (comm. 9, Thomas & Benson 1985); BWP- Brisbane Water NP (comm. 4, Benson & Fallding 1981).

Region:	Cn	Ms	Cn	LBM	UBM	Mn	Ch	Ch	Co	Tot
Locality:	OHE	OHW	RNP	BBP	KAT	YNP	DNP	GNP	KCP	BWP
Trees										
<i>Angophora bakeri</i>						x				1
<i>Angophora costata</i>	X	X	X	X		X	X	X	X	9
<i>Angophora floribunda</i>						x			x	2
<i>Eucalyptus agglomerata</i>	x	X	x	x		x	x			6
<i>Eucalyptus capiteolata</i>									x	1
<i>Eucalyptus consideniana</i>		x								1
<i>Eucalyptus eugenioides</i>				x						1
<i>Eucalyptus eximia</i>				x		x	x		x	5
<i>Eucalyptus gummifera</i>	x	X	x	X		x	x	X	X	9
<i>Eucalyptus haemastoma</i>									x	2
<i>Eucalyptus multicaulis</i>		x								1
<i>Eucalyptus oblonga</i>	x	x							x	4
<i>Eucalyptus oreades</i>				X						1
<i>Eucalyptus pellita</i>									x	1
<i>Eucalyptus pilularis</i>		x		X		X				3
<i>Eucalyptus piperita</i>	X	x	X		X	X	X	X	X	9
<i>Eucalyptus punctata</i>		X	x	x		x	x		x	7

b) Forest on Hawkesbury Shale caps. Regions after Pidgeon (1941): Cn- Coastal, Nepean Ramp sub-region; Ch- Coastal, Hornsby Plateau sub-region; Co- Coastal, Ourimbah sub-region. Localities: O'Hares Creek catchment (comm. SF, this study); RNP- Royal NP (Keith unpubl. data); GNP- Garrigal NP (map units 10 & 12, Sherringham & Sanders 1993); KCP- Ku-ring-gai Chase NP (comm. 8, Thomas & Benson 1985); BWP- Brisbane Water NP (comm. 45, Benson & Fallding 1981).

Region:	Cn	Cn	Ch	Ch	Co	Total
Locality:	OHC	RNP	GNP	KCP	BWP	
Trees						
<i>Angophora costata</i>	X	x	X	X	X	5
<i>Eucalyptus capitellata</i>			X			1
<i>Eucalyptus globoides</i>	X	X			x	3
<i>Eucalyptus gummiifera</i>	X	x	X		X	4
<i>Eucalyptus haemastoma</i>					x	1
<i>Eucalyptus oblonga</i>					x	1
<i>Eucalyptus paniculata</i>		x				1
<i>Eucalyptus pilularis</i>		X	X	X		2
<i>Eucalyptus piperita</i>	X					1
<i>Eucalyptus punctata</i>				X		1
<i>Eucalyptus resinifera</i>		x		x		2
<i>Eucalyptus saligna</i>	x					1
<i>Eucalyptus sieberi</i>	x		X			2
<i>Eucalyptus umbra</i> ssp. <i>umbra</i>			X		x	2
<i>Syncarpia glomulifera</i>		x		x	x	3

O'Hares Creek catchment contains plant communities that are not well sampled in existing conservation reserves on Sydney sandstone (Table 6, Appendix 1). These include the five upland swamp communities, Shale Forest, Western Gully Forest, Ironstone Woodland, Heath Woodland and Rock Pavement Heath. Sandstone Woodland and Eastern Gully Forest are comparatively well represented in reserves. Stands of Mallee Heath and Ironstone Heath are significant because these represent the southern distributional limits of these community types. Examples of Riparian Scrub in O'Hares Creek catchment are unaffected by weed invasion, unlike many comparable stands within reserves where runoff is polluted by urban and industrial development in upper catchments. Overall levels of disturbance are minimal and the introduced flora is small, though both are increasing in recent years mainly as a result of mining activities. Disturbed areas such as clay quarries and tracks regenerate over time with native species, though not necessarily to their original species composition. Exceptions with significant weed invasion include sites exposed to frequent vehicular use (e.g. Bulli–Appin Rd) and sites exposed to enriched moisture and/or nutrients (e.g. mine effluent irrigation sites, rural interfaces).

O'Hares Creek Catchment includes a large number (17) of nationally rare or threatened plant taxa (Table 2). For three of the most restricted taxa (*Pultenaea aristata*, *Leucopogon exolasius* and *Grevillea longifolia*) the area contains major populations, whose maintenance is important for overall conservation of these species. O'Hares Creek is also an important biogeographic location for eleven taxa that reach their southern limit of distribution in the area, including seven Sydney sandstone endemics and two species that extend well north of Sydney along coastal sands. The population of *Callitris endlicheri* is also of biogeographic significance. Its presence in an area that receives two to three times the average annual rainfall of typical *C. endlicheri* habitat, and its isolation from other populations of the species, suggest that it persists as a relic of populations that were more widespread during a drier late Pleistocene climate.

A large volume of biological and geomorphological data has been gathered in O'Hares Creek area since Allan Cunningham made his early collections. Completed studies address topics of stream dynamics and landscape evolution (Harden 1965), upland swamp geomorphology and palynology (Young 1983, 1986a,b), vegetation patterns and dynamics (Davis 1936, 1941, Keith 1991, Keith & Myerscough 1993), rare plant ecology (Andren et al. 1987, Auld et al. 1993) and koala ecology (Cork et al. 1988, Close 1993). Further studies in fire ecology, plant reproductive biology and ecological modelling are in progress. Universities of Sydney and Wollongong use the area for practical components of undergraduate courses on ecology and conservation biology. These studies and a geographic information system developed as part of the current work underpin the value of O'Hares Creek catchment as a scientific reference area and as an important augmentation to the regional network of conservation reserves.

Acknowledgements

Mark Tozer assisted with GIS management and prepared the map and figures. Mark, with assistance from Lisa Metcalfe, overcame many technical difficulties to develop the procedure for translating GIS map data into a final publishable layout. The first fully computer-generated vegetation map published in *Cunninghamia* is his innovative contribution. Vegetation boundaries were digitised by David Eckstein. Belinda Pellow and Elizabeth Ashby assisted with data collection. George Williams of the Sydney Water Board provided logistic support and local knowledge in the field. Peter Myerscough, Dominic Sivertsen and Peter Clarke commented on the draft.

References

- Andren, M., Chaffe, C., Stephens, K. & Telford, E. (1987) Rare plants of the Metropolitan, O'Hares and Woronora water catchment areas. In Telford, E., Marthick, J., Russel, D. & Lambkin, K. (eds.) *Environmental science studies in ecology*. (University of Wollongong: Wollongong).
- Auld, T.D., Bradstock, R.A. & Keith, D.A. (1993) *Fire as a threat to populations of rare plants. Endangered Species Project No. 31*. Australian National Parks & Wildlife Service Endangered Species Program.
- Beadle, N.C.W. (1954) Soil phosphate and the delimitation of plant communities in eastern Australia I. *Ecology* 35: 370-375.
- Beadle, N.C.W. (1962) Soil phosphate and the delimitation of plant communities in eastern Australia II. *Ecology* 43: 281-288.
- Bedward, M., Keith, D.A. & Pressey, R.L. (1992) Homogeneity analysis: assessing the utility of classifications and maps of natural resources. *Australian Journal of Ecology* 17: 133-139.
- Belbin, L. & McDonald, C. (1993) Comparing three classification strategies for use in ecology. *Journal of Vegetation Science* 4: 341-348.
- Benson, D.H., Burkitt, J. & Thomas, J. (1990) The natural vegetation of Bents Basin State Recreation Area. *Cunninghamia* 2: 223-262.
- Benson, J.S. & Fallding, H. (1981) Vegetation survey of Brisbane Water National Park. *Cunninghamia* 1: 79-113.
- Binns, D. & Chapman, W. (1992) Flora survey, Wingham management area, Port Macquarie region. Forest Resources Series No. 18. Forestry Commission of NSW.
- Bowman, H. N., Stroud, W. J., Sherwin, L. & Ray, H. N. (1986) Sydney Basin stratigraphy. In Sherwin, L. and Holmes, G.G. (eds.) *Geology of the Wollongong and Port Hacking 1:100,000 sheets*. (Geological Survey of New South Wales: Sydney).
- Briggs, J.D. & Leigh, J.L. (1988) *Rare or threatened Australian plants*. Special Publication No. 14. (Australian National Parks & Wildlife Service: Canberra).
- Buchanan, R. A. (1980). The Lambert Peninsula Ku-ring-gai Chase National Park. Physiography and the distribution of podzols, shrublands and swamps, with details of swamp vegetation and sediments. *Proceedings of the Linnean Society of New South Wales* 104: 73-94.
- Burrough, P.A., Brown, L. & Morris, E.C. (1977) Variations in vegetation and soil pattern across the Hawkesbury Sandstone plateau from Barren Grounds to Fitzroy Falls, New South Wales. *Australian Journal of Ecology* 2: 137-159.
- Clarke, P.J. & Benson, D.H. (1986) Vegetation survey of Dharug National Park. National Herbarium of NSW, Royal Botanic Gardens, Sydney.
- Clements, A. (1983) Suburban development and resultant changes in the vegetation of the bushland of the northern Sydney region. *Australian Journal of Ecology* 8: 307-319.
- Close, R. (1993) Campbelltown koalas: what is their future? *National Parks Journal* 37: 22-25.
- Cork, S.J., Margules, C.R. & Braithwaite, L.W. (1988) *A survey of koalas and their habitat near Wedderburn N.S.W., suggestions for management, and an assessment of the potential effects of a proposed subdivision of four-hectare environmental lots*. (CSIRO Division of Wildlife and Ecology: Canberra).
- Davis, C. (1936) Plant ecology of the Bulli district I: Stratigraphy, physiography and climate; general description of plant communities and interpretation. *Proceedings of the Linnean Society of New South Wales* 61: 285-297.
- Davis, C. (1941) Plant Ecology of the Bulli district II: Plant communities of the plateau and scarp. *Proceedings of the Linnean Society of New South Wales* 66: 1-19.
- Faith, D.P., Minchin, P.R. & Belbin, L. (1987) Compositional dissimilarity as a robust measure of ecological distance: a theoretical model and computer simulations. *Vegetatio* 69: 57-68.
- Griffith, S.J. (1988) A survey of the vegetation of Yuraygir National Park. NSW National Parks & Wildlife Service.
- Harden, R.W. (1965) *Some aspects of the fluvial morphology of the upper Georges River basin*. MSc thesis. University of Sydney.
- Harden, G. (1990, 1991, 1992, 1993) *Flora of New South Wales Volumes 1-4*. (University of New South Wales Press: Kensington).
- Hill, M.O. (1978) *TWINSPAN: A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes*. Section of Ecology and Systematics. (New York: Cornell University).

- Hovenden, M. (1989) *Serotinous seed bank of Hakea dactyloides* (Gaertner) Cav: its characteristics and responses. BSc(Hons.) thesis. University of Sydney.
- Keith, D.A. (1991) Coexistence and species diversity in upland swamp vegetation: the roles of an environmental gradient and recurring fires. PhD thesis. University of Sydney.
- Keith, D.A. & Benson, D.H. (1988) Natural vegetation of the Katoomba 1:100 000 map sheet. *Cunninghamia* 2: 107–143.
- Keith, D.A. & Myerscough, P.J. (1993) Floristics and soil relations of upland swamp vegetation near Sydney. *Australian Journal of Ecology* 18: 325–344.
- Keith, D.A. & Sanders, J.M. (1990) Vegetation of the Eden region, south-eastern New South Wales, Australia. *Journal of Vegetation Science* 1: 203–232.
- Krauss, S. (1994) Variation in *Leptospermum trinervium* (Myrtaceae): a problem species and the species problem. *Australian Systematic Botany* 7: 251–263.
- Lance, G.N. & Williams, W.T. (1967) A general theory of classificatory sorting strategies I. Hierarchical systems. *Computing Journal* 9: 373–380.
- Lee, I. (1925) *Early explorers in Australia*. (Methuen: London).
- Minchin, P.R. (1987). An evaluation of the relative robustness of techniques for ecological ordination. *Vegetatio* 69: 89–107.
- Minchin, P.R. (1991) DECODA: Database for Ecological Community Data. Version 2.04. Australian National University.
- Peet, R.K. (1978) Forest vegetation on the Colorado Front Range: patterns of species diversity. *Vegetatio* 37: 65–78.
- Pidgeon, I. (1938) The ecology of the central coast area of New South Wales. II. Plant succession on the Hawkesbury Sandstone. *Proceedings of the Linnean Society of New South Wales* 63: 1–26.
- Pidgeon, I. (1941) The ecology of the central coast area of New South Wales. IV. Forest types on soils from Hawkesbury Sandstone and Wianamatta Shale. *Proceedings of the Linnean Society of New South Wales* 66: 113–137.
- Poore, M. E. D. (1955) The use of phytosociological methods in ecological investigations. I. The Braun-blauquet system. *Journal of Ecology* 43: 226–244.
- Sanders, J.M., Bedward, M., Leahy, B., Robinson, M. & Sherringham, P. (1988) Preliminary report on the vegetation of Yengo National Park and Parr State Recreation Area. NSW National Parks and Wildlife Service.
- Sherringham, P.R. & Sanders, J.M. (1993) Vegetation survey of Garrigal National Park and surrounding crown lands. NSW National Parks & Wildlife Service.
- Sherwin, L., Walsh, I.L., Roy, P.S. & Hann, J. (1986) Cainozoic sediments. In Sherwin, L. & Holmes, G.G. (eds). *Geology of the Wollongong and Port Hacking 1:100,000 sheets*. Geological Survey of New South Wales: Sydney).
- Thomas, J. & Benson, D.H. (1985) Vegetation survey of Ku-ring-gai Chase National Park. National Herbarium of NSW, Royal Botanic Gardens, Sydney.
- Young, A.R.M. (1983) Upland swamps (dells) on the Woronora Plateau, NSW. PhD thesis. University of Wollongong.
- Young, A.R.M. (1986a) The geomorphic development of dells (upland swamps) on the Woronora Plateau, NSW, Australia. *Zeitschrift für Geomorphologie* 30: 317–327.
- Young, A.R.M. (1986b) Quaternary sedimentation on the Woronora Plateau and its implications for climatic change. *Australian Geographer* 17: 1–5.

Manuscript received 21 September 1993

Manuscript accepted 14 March 1994

Appendix 1: Description of Plant Communities

SF Shale Forest (Figure 7)

Samples: 1,2,3,4,5,6,7,8.

Habitat: Deep, well-drained red loam on outcrops of Hawkesbury Shale. Flat ridgetops and adjacent slopes.

Distribution: 176 ha (1.9% of study area). Restricted to patches on broad ridges in the eastern third of the catchment.

Trees: 20 m tall, 39% cover; *Eucalyptus globoidea* is exclusive to this community. *Angophora costata*, *E. piperita* and *E. gummifera* co-occur in various combinations. Rare occurrences of *Eucalyptus saligna*.

Shrubs: 5 m tall, 13% cover; *Acacia binervata*, *A. longifolia*, *Pultenaea linophylla*, *P. hispidula* and *Olearia erubescens* are exclusive. Other common taxa include *Banksia spinulosa*, *Lomatia silaifolia*, *Phyllanthus hirtella*, *Ozothamnus diosmifolius*, *Hibbertia empetrifolia*, *Leucopogon lanceolata* and *Persoonia linearis*.

Groundcover: 0.8 m tall, 54% cover; dominated by grasses, forbs, vines and ferns. *Themeda australis*, *Pratia purpurascens*, *Pterostylis grandiflora*, *Viola betonicifolia*, *Goodenia heterophylla*, *Eustrephus latifolius*, *Kennedia rubicunda*, *Clematis aristata* and *Comesperma volubile* are exclusive. Other common taxa include *Imperata cylindrica*, *Dichelachne rara*, *Brunoniella pumilio*, *Lagenifera stipitata*, *Doryanthes excelsa*, *Lomandra longifolia*, *Lepidosperma laterale*, *Glycine clandestina*, *Blechnum cartilagineum* and *Calochlaena dubia*.

Variability: Samples on the Darkes Forest ridge are typified by a more mesic understorey than on smaller shale outcrops further west.



Figure 7. Shale Forest dominated by *Eucalyptus globoidea* with dense stands of *Doryanthes excelsa* and native grasses in the understorey.

Disturbance: Most stands have been selectively logged for fencing and firewood. The patch at Darkes Forest has been partly cleared for agricultural uses. Three other stands have been partly cleared for clay quarry operations.

Conservation: Shale Forest is important locally as habitat because it differs in markedly in composition and structure from surrounding vegetation on sandstone. Regionally, isolated stands of O'Hares Creek Shale Forest is transitional between more mesic escarpment forests on Narrabeen shales to the east and drier Cumberland Plain woodlands on Wianamatta shales to the west. However, widespread elements of the escarpment forests (e.g. *Eucalyptus pilularis*, *Syncarpia glomulifera*) and the plain woodlands (e.g. *Eucalyptus moluccana*, *Bursaria spinosa*) are absent from the O'Hares Creek Shale Forest, and some species found in the latter (e.g. *Pultenaea hispidula*) are poorly represented on the escarpment and plain. Forests occur on Hawkesbury Shale further north, but have a restricted distribution, and differ in floristic composition from those at O'Hares Creek (Table 6b). Such forests at Sutherland–Cronulla, Engadine, Frenchs Forest and Duffeys Forest have been cleared, while smaller patches such as those at Menai and Helensburgh retain forests under threat from urban development. Small, but differing stands are reserved near Loftus (Keith unpubl.) and near Wondabyne (Benson & Fallding 1981).

WGF Western Gully Forest

Samples: 9,10,11,26,33,34,35,36,43.

Habitat: Sheltered slopes of major sandstone gullies and restricted patches on narrow ridges (possibly with relictual shale influence). Soils are shallow, well-drained, moist sands and sandy loams.

Distribution: 822 ha (8.7% of study area). Gullies and adjacent ridges in western part of catchment.

Trees: 20 m tall, 31% cover; *Eucalyptus punctata* and *E. pilularis* occur exclusively in gullies in this community, while *E. consideniana* and *E. multicaulis* are exclusive to ridgetops. Other taxa include *E. agglomerata* and *Angophora costata* in gullies, and *E. gummifera* and *E. oblonga* on ridgetops.

Shrubs: 2.2 m tall, 43% cover; *Exocarpos strictus* and *Pomaderris lanigera* are exclusive. Other common taxa include *Banksia spinulosa*, *Dodonaea triquetra*, *Pultenaea flexilis*, *Lissanthe strigosa*, *Dillwynia retorta*, *Bossiaea heterophylla*, *Leptospermum trinervium* (narrow-leaved form), *Petrophile sessilis*, *Grevillea mucronulata*, *Persoonia linearis*, *P. levis*, *Platysace linearifolia* and *Eriostemon australasius*.

Groundcover: 0.4 m tall, 16% cover; *Aristida vagans* and *Xanthorrhoea concava* are exclusive. Other common taxa include *Acianthus fornicatus*, *Entolasia stricta*, *Caustis flexuosa* and *Pomax umbellata*.

Variability: In gullies the tree stratum is taller and includes *Eucalyptus punctata*, *E. pilularis*, *E. agglomerata* and *Angophora costata* (samples 11,26,33,35,36). Stands on ridges are restricted and include *E. consideniana*, *E. multicaulis*, *E. gummifera* and *E. oblonga* (samples 10,11,34,43).

Disturbance: Selective logging in small accessible areas.

Conservation: The community is likely to extend along the western edge of the Woronora Plateau to the Holsworthy Military Area in the north and Water Board catchments in the south. Similar communities may occur in conservation reserves in the Nattai area and lower Blue Mountains, although some differences in composition may be expected. Near Wedderburn, Western Gully Forest is habitat for a significant population of koalas (Cork et al. 1988, Close 1993).

EGF Eastern Gully Forest (Figure 8)

Samples: 23,25,27,28,29,30,31,32

Habitat: Sheltered slopes of major sandstone gullies. Soils are shallow, well-drained, moist sands and sandy loams.

Distribution: 1562 ha (16.6% of study area). Gullies in the eastern part of the catchment.

Trees: 20 m tall, 28% cover; *Eucalyptus piperita* with *Angophora costata*, *E. gummifera* and *E. sieberi*.

Shrubs: 3.0 m tall, 37% cover; *Banksia cunninghamii* is exclusive to this community. Other common taxa



Figure 8. Eastern Gully Forest dominated by *Eucalyptus piperita* (foreground) and *Angophora costata* (smooth bark) with dense understorey of proteaceous, myrtaceous and fabaceous shrubs.



Figure 9. Riparian Scrub with *Leptospermum morrisonii*, *Tristaniopsis laurina* and other myrtaceous shrubs.

include *Aotus ericoides*, *Zieria laevigata*, *Hakea dactyloides* (single-stemmed form), *Monotoca scoparia*, *Hibbertia monogyne*, *Banksia serrata*, *Lambertia formosa*, *Persoonia pinifolia*, *P. levis*, *Platysace linearifolia*, *Acacia ulicifolia*, *Eriostemon australasius* and *Leptomeria acida*.

Groundcover: 0.7 m tall, 11% cover; *Lycopodium deuterodensum*, *Stylidium productum*, *Chloanthes stoechardis* and *Gahnia radula* are exclusive. Other common taxa include *Xanthosia pilosa* (entire-leafed form), *Gonocarpus teucroides*, *Smilax glycyphylla*, *Cassytha pubescens*, *Lomandra gracilis*, *Patersonia glabrata*, *Lepidosperma laterale* and *Lepyrodia scariosa*.

Disturbance: No obvious disturbance.

Conservation: Similar vegetation is represented within Heathcote and Royal NPs (Keith unpubl. data). Forests in sandstone gullies further south are without *A. costata*, but otherwise similar. Reserves north and west of Sydney sample large areas of forest in sandstone gullies, but these differ in composition (Table 6a).

RS Riparian Scrub (Figure 9)

Samples: 19,20,21,22; outliers: 18,24.

Habitat: Moist, sandy alluvium amongst rocks along major creeks.

Distribution: 216 ha (2.3% of study area). O'Hares and Stokes Creeks and their major tributaries.

Trees: Typically none.

Shrubs: 4.1 m tall, 40% cover; *Tristaniopsis laurina*, *Tristania neriifolia*, *Leptospermum morrisonii*, *Ceratopetalum apetalum*, *Pseudanthus pimelioides*, *Lomatia myricoides*, *Prostanthera linearis*, *Phebalium dentatum*, *P. squamulosum* and *Micrantheum hexandrum* are exclusive to this community. Other common taxa include *Acacia obtusifolia*, *A. irrorata*, *Monotoca scoparia*, *Bauera rubioides* and *Grevillea longifolia*.

Groundcover: 0.6 m tall, 24% cover; *Lomandra fluviatilis* is exclusive. Other common taxa include *Restio dimorphus*, *Sticherus flabellatus*, *Lomandra longifolia* and *Lepidosperma laterale*.

Variability: Sheltered, rocky sites support tall scrub dominated by *T. laurina* and *C. apetalum*. Open sandy sites support heath with various smaller shrubs. Samples 18 & 24, on sandstone slopes adjacent to creeks, are intermediate in composition between Riparian Scrub and Eastern Gully Forest.

Disturbance: Small weirs on O'Hares and Stokes record stream flow. Each creek is also crossed by one ford. Otherwise, no evidence of disturbance. No exotic species recorded.

Conservation: Similar vegetation is represented in Royal and Heathcote NPs, as well as other sandstone reserves. However, O'Hares Creek catchment includes an example that is significant because of its condition, much riparian vegetation on Sydney sandstone being infested with weeds.

IW Ironstone Woodland (Figure 10)

Samples: 12,13,14,15.

Habitat: Flat areas of the plateau with a thick mantle of ironstone. Soils are well-drained red loams.

Distribution: 297 ha (3.2% of study area). Restricted to 2 main patches. Along 10B fire trail between Appin Rd and 10C fire trail and from the head of O'Hares Creek to Maddens Plains.

Trees: 13 m tall, 17% cover; *Eucalyptus sieberi* is most abundant in this community. Other common taxa include *E. racemosa* and *E. gummifera*.

Shrubs: 1.5 m tall, 44% cover; *Acacia myrtifolia*, *Daviesia corymbosa* and *Banksia paludosa* are most abundant in this community. Other common taxa include *Lambertia formosa*, *Hakea dactyloides* (multi-stemmed form), *Persoonia levis*, *Gompholobium grandifolium* and *Pimelea linifolia*.



Figure 10. Ironstone Woodland with *Eucalyptus sieberi* (left), *E. racemosa* (right) and mallee *E. gummifera*. The understorey is dominated by shrubs in the Fabaceae and Proteaceae.



Figure 11. Sandstone Woodland near Wedderburn with *Eucalyptus gummifera* (right) and *E. oblonga* (centre) and a diverse shrubby understorey. Sandstone Woodland and Western Gully Forest provide habitat for a population of koalas in this area.

Groundcover: 0.4 m tall, 23% cover; *Dampiera stricta*, *Gonocarpus tetragynus*, *Patersonia glabrata* and *Anisopogon avenaceus*.

Disturbance: Small borrow pits for gravel.

Conservation: Limited stands of similar vegetation in Royal NP (Keith unpubl. data), Garigal NP (map unit 11, Sherringham & Sanders 1993), Ku-ring-gai Chase NP (comm. 10, Thomas & Benson 1985) and around Warrah trig in Brisbane Water NP (comm. 4P, Benson & Fallding 1981).

SW Sandstone Woodland (Figure 11)

Samples: 37,38,42,47; outliers 39,40.

Habitat: Flat and undulating sandstone ridges and plateau tops. Soils are well-drained shallow sandy loams.

Distribution: 4446 ha (47.2% of study area). Widespread throughout catchment.

Trees: 9.5 m tall, 22% cover; *Eucalyptus oblonga* is characteristic of this community. Other trees include *E. gummifera*, *E. racemosa* and *E. sieberi*.

Shrubs: 1.2 m tall, 35% cover; *Bossiaea obcordata* is exclusive. Other common taxa include *Banksia spinulosa*, *B. marginata*, *B. serrata*, *Conospermum longifolium* var. *angustifolium*, *Grevillea sphacelata*, *Persoonia pinifolia*, *P. levis*, *Leptospermum trinervium* (narrow-leaved form), *Platysace ericoides*, *Hakea dactyloides* (multi-stemmed form), *Isopogon anemonifolius*, *Bossiaea heterophylla*, *Eriostemon australasius* and *Phyllota phyllicoides*.

Groundcover: 0.4 m tall, 23% cover; common taxa include *Caustis flexuosa*, *Dampiera stricta*, *Lomandra glauca*, *Xanthorrhoea media* and *Cyathochaeta diandra*.

Variability: Closely related to Mallee Heath and Ironstone Woodland. Samples 39 & 40 are less clearly differentiated from these related communities than the other four samples.

Disturbance: Localised clearing for mine ventilation shafts, otherwise no obvious disturbance.

Conservation: Similar vegetation is represented within Royal, Heathcote and Garrawarra NPs and in Water Board catchments elsewhere on the Woronora Plateau (Keith unpubl. data). Analogous communities are widespread on sandstone plateaux north and west of Sydney (e.g. comm. 6 of Benson & Fallding (1981), 15 of Thomas & Benson (1985), C2 of Clarke & Benson (1986), 10ar of Keith & Benson (1988), map unit 7 of Sherringham & Sanders (1993)).

HW Heath Woodland

Samples: 44,45,46.

Habitat: Broad, flat plateau tops with an ironstone mantle overlying sandstone. Soils are damp, shallow sandy loams.

Distribution: 156 ha (1.7% of study area). Two main patches: along 10B fire trail between its junction with 10C and 10K trails; and along 10H fire trail near its junction with Darkes Forest Road.

Trees: 9.0 m tall, 7% cover; *Eucalyptus haemastoma* is dominant, *E. gummifera* in its mallee growth form is common, infrequent taxa include *E. racemosa*, *E. sieberi* and *E. oblonga*.

Shrubs: 1.2 m tall, 38% cover; *Petrophile pulchella*, *Banksia oblongifolia*, *Persoonia pinifolia*, *Hakea dactyloides* (multi-stemmed form), *Pimelea linifolia*, *Isopogon anemonifolius*, *Lambertia formosa*, *Grevillea oleoides*, *Hemigenia purpurea*, *Leucopogon esquamatus* and *Leptospermum trinervium* (broad-leaved form) are common taxa.

Groundcover: 0.4 m tall, 37% cover; *Patersonia glabrata*, *P. sericea*, *Lindsaea linearis*, *Lomandra obliqua*, *Cyathochaeta diandra*, *Lepyrodia scariosa*, *Ptilanthelium deustum*, *Schoenus pachylepis*, *Leptocarpus tenax*, *Mitrasacme polymorpha*, *Dampiera stricta*, *Xyris gracilis* ssp. *laxa*, *Xanthorrhoea media*, *Gonocar-*



Figure 12. Ironstone Heath dominated by *Angophora hispida*, *Banksia oblongifolia* (bottom left) and emergent *Leptospermum trinervium*. Groundcover consists of graminoid and lilioid taxa.



Figure 13. Mallee Heath dominated by *Eucalyptus luehmanniana*. *Banksia ericifolia* is conspicuous in the diverse understorey.

pus tetragynus, *Anisopogon avenaceus*, *Actinotus minor*, *Mirbelia rubiifolia*, *Cassytha glabella*, *Selaginella uliginosa*, *Goodenia bellidifolia*, *Xanthosia tridentata*, *Thysanotus juncifolius* and *Drosera peltata* are common taxa.

Disturbance: Localised patches cleared for army bivouacs.

Conservation: Limited stands represented in Royal NP (Keith unpubl. data). Larger stands in the Menai-Holsworthy area. Analogous vegetation types have been described on the Hornsby Plateau, but these are restricted in area (e.g. community C3 of Clarke & Benson (1986), map unit 6 of Sanders & Sherringham (1993)).

IH Ironstone Heath (Figure 12)

Samples: 16,17.

Habitat: Broad, flat plateau top with an ironstone mantle overlying sandstone. Soils are damp, shallow sandy loams.

Distribution: 12 ha (0.1% of study area). One small patch near 10B trig.

Shrubs: 1.0 m tall, 50% cover; *Angophora hispida*, *Hakea dactyloides* (multi-stemmed form), *Lomatia silaifolia*, *Pultenaea elliptica* (red-flowered form), *Conospermum taxifolium*, *Brachyloma daphnoides*, *Kunzea capitata* and *Eucalyptus haemastoma* are characteristic of this community. Other common taxa include *Hibbertia serpyllifolia*, *Acacia suaveolens*, *Leptospermum arachnoides*, *Petrophile pulchella*, *Pimelea linifolia*, *Isopogon anemonifolius*, *Lambertia formosa*, *Banksia oblongifolia*, *B. paludosa*, *Daviesia corymbosa*, *Grevillea oleoides*, *Persoonia levis*, *Platysace linearifolia*, *Eriostemon australasius*, *Leucopogon esquamatus* and *Leptospermum trinervium* (broad-leaved form).

Groundcover: 0.5 m tall, 20% cover; *Cyathochaeta diandra*, *Ptilantherium deustum*, *Schoenus pachylepis*, *Patersonia glabrata*, *P. sericea*, *Scaevola ramosissima*, *Platysace ericoides*, *Dampiera stricta*, *Lomandra glauca*, *L. obliqua*, *Xyris gracilis* ssp. *laxa*, *Xanthorrhoea media*, *Gonocarpus tetragynus*, *Anisopogon avenaceus*, *Lindsaea linearis*, *Haemadorum corymbosum*, *Lepyrodia scariosa*, *Tricostularia pauciflora*, *Mirbelia rubiifolia*, *Cassytha glabella*, *Xanthosia tridentata*, *Drosera peltata*, *Burchardia umbellata*, *Sowerbaea juncea* and *Blandfordia nobilis*.

Variability: Closely related to woodland heath, but treeless.

Disturbance: Small area cleared for road gravel extraction.

Conservation: Larger areas in the north of Holsworthy Military Area to Menai area. Several patches represented in Royal NP, though these heathlands are more variable in composition (Keith unpubl. data). Heathlands in Ku-ring-gai Chase, Dharug and Garrigal NPs share some species, but differ in overall composition (Thomas & Benson 1985, Sherringham & Sanders 1993, Clarke & Benson 1986).

MH Mallee Heath (Figure 13)

Sites: 41,48,49,50,52.

Habitat: Stoney sandstone ridgetops with shallow, well-drained sandy loams.

Distribution: 28 ha (0.3% of study area). Small patches scattered in eastern part of catchment.

Trees: 4–8 m tall, 22% cover; *Eucalyptus luehmanniana* is characteristic of this community, *E. gummifera* (mallee growth form) is common.

Shrubs: 1.2 m tall, 35% cover, *Leucopogon microphyllus*, *Epacris microphylla*, *Leptospermum trinervium* (narrow-leaved form), *L. arachnoides*, *Monotoca scoparia*, *Acacia suaveolens*, *Petrophile pulchella*, *Hakea dactyloides* (multi-stemmed form), *Pimelea linifolia*, *Banksia ericifolia*, *B. serrata*, *B. oblongifolia*, *Hibbertia serpyllifolia*, *Daviesia corymbosa*, *Grevillea oleoides*, *Acacia ulicifolia*, *Platysace linearifolia*, *Eriostemon australasius*, *Xanthosia tridentata* and *Kunzea capitata*.

Groundcover: 0.4 m tall, 23% cover; *Entolasia stricta*, *Scaevola ramosissima*, *Dampiera stricta*, *Lomandra glauca*, *L. obliqua*, *Xyris gracilis* ssp. *laxa*, *Xanthorrhoea media*, *Bossiaea ensata*, *Gonocarpus tetragynus*, *Anisopogon avenaceus*, *Lindsaea linearis*, *Cyathochaeta diandra*, *Actinotus minor* and *Lepyrodia scariosa*.

Variability: Closely related to Sandstone Woodland.

Disturbance: No obvious disturbance.

Conservation: Mallee heath dominated by *E. luehmanniana* and *E. gummifera* is represented within Royal NP (Keith unpubl. data), Garrigal NP (map unit 5 of Sherringham & Sanders 1993), Ku-ring-gai Chase NP (community 16 of Thomas & Benson 1985) and Brisbane Water NP (part of community 6 of Benson & Fallding 1981). However, there are minor differences in understorey floristics and the community is locally restricted in these areas, as it is in O'Hares Creek catchment where it reaches its southern limit.

RPH Rock Pavement Heath

Sites: 51,53,54,55,56.

Habitat: Massive sandstone pavements on the plateau. Soils are skeletal, sandy and damp to very dry, depending on recent weather.

Distribution: 11 ha (0.1% of study area). Restricted to a few very small patches in the eastern and southern part of the catchment.

Shrubs: 1.5 m tall, 35% cover; *Monotoca ledifolia* is exclusive to this community. Characteristic taxa include *Kunzea ambigua* and *Darwinia fascicularis*. *Persoonia pinifolia* is also present.

Groundcover: 0.5 m tall, 9% cover; *Lepidosperma viscidum* (red-gum form) and *Thelionema umbellatum* are exclusive. *Lepyrodia scariosa* is also present.

Variability: Few species occur consistently across most sites.

Disturbance: No obvious disturbance.

Conservation: Similar heath occurs in Royal NP (Keith unpubl. data). Heath on rock pavements north of Sydney differs in some of the major species (notably *Baeckea* spp.). Examples include community 18 of Thomas & Benson (1985), map unit 1 of Sherringham & Sanders (1993), community C5 of Clarke & Benson (1986) and community 9 of Benson & Fallding (1981). All these communities are highly restricted.

BT Banksia Thicket

Sites: S3,S14,S18,S31,S37,S48,S53.

Habitat: Upper slopes of large upland swamps. Soils are damp, shallow sandy loams.

Distribution: 95 ha (1.0% of study area). Patches restricted to southern part of catchment.

Shrubs: 3.4 m tall, 75% cover; *Banksia ericifolia* and *Hakea teretifolia* (single-stemmed form) are dominant and, with *Pultenaea aristata*, characteristic of this community. Other common taxa include *Banksia oblongifolia*, *Dillwynia floribunda* and *Grevillea oleoides*.

Groundcover: 0.6 m tall, 55% cover, *Tetrarrhena turfosa*, *Selaginella uliginosa*, *Lindsaea linearis*, *Empodisma minus*, *Gonocarpus tetragynus*, *Dampiera stricta*, *Lepidosperma neesii*, *Ptilanthelium deustum*, *Leptocarpus tenax*, *Lepyrodia scariosa*, *Schoenus brevifolius*, *Cassytha glabella*, *Entolasia stricta* and *Xanthorrhoea resinifera*.

Variability: Distribution, structure and composition vary depending on fire history. Frequent fires eliminate the overstorey or reduce its density (Keith 1991). Some stands include emergent eucalypts of Sandstone Woodland.

Disturbance: No obvious disturbance.

Conservation: Examples further south may be limited. Analogous communities further north in Royal NP (Keith unpubl. data), Ku-ring-gai Chase NP (community 17 of Thomas & Benson 1985), Garrigal NP (map unit 3 of Sherringham & Sanders 1993) and Brisbane Water NP (community 8 of Benson & Fallding 1981). However, these latter communities differ in composition, notably in the presence of *Allocasuarina distyla* as co-dominant.

SHC Sedgeland-Heath Complex (Figure 14)

– RH. Restioid Heath

Sites: S4,S6,S8,S9,S17,S2,S32,S36,S38,S39,S44,S47,S51,S52,S55.

Habitat: Damp upper slopes of large upland swamps or widespread in swamps without major seepage zones. Soils are occasionally waterlogged shallow sandy loams.

Distribution: Patches scattered throughout the south and east of the catchment. Restioid Heath occupies ca. 60% of the Heath-Sedgeland Mosaic (860 ha, 9.1% of study area).

Shrubs: 0.9 m tall, 38% cover; *Banksia oblongifolia*, *Hakea teretifolia* (multi-stemmed form), *Cryptandra ericoides* and *Grevillea parviflora* are characteristic of this community. Other common taxa include *Grevillea oleoides*, *Conospermum ellipticum*, *Bauera microphylla* and *Epacris obtusifolia*.

Groundcover: 0.6 m tall, 77% cover; *Lomandra filiformis* ssp. *filiformis*, *L. cylindrica*, *Plinthanthesis paradoxa*, *Burchardia umbellata*, *Patersonia* sp. aff. *fragilis*, *P. sericea* and *Haemadorum corymbosum* are characteristic. Other common taxa include *Stackhousia nuda*, *Thysanotus juncifolius*, *Lepidosperma neesii*, *Lindsaea linearis*, *Gonocarpus tetragynus*, *Dampiera stricta*, *Drosera spathulata*, *Goodenia bellidifolia*, *G. dimorpha* var. *angustifolia*, *Stylidium lineare*, *Sowerbaea juncea*, *Blandfordia nobilis*, *Mitrasacme polymorpha*, *Ptilanthelium deustum*, *Leptocarpus tenax*, *Lepyrodia scariosa*, *Empodisma minus*, *Schoenus*



Figure 14. Sedgeland-Heath Complex at Maddens Plains showing Restioid Heath (foreground) with *Xanthorrhoea resinifera* and *Banksia oblongifolia*, grading into Cyperoid Heath (middle distance). The drainage line in the distance supports Ti-tree Thicket.

brevifolius, *Cassytha glabella*, *Entolasia stricta*, *Xanthorrhoea resinifera*, *Xyris gracilis* ssp. *laxa* and *X. operculata*.

Disturbance: Small patches excavated for clay extraction, otherwise undisturbed.

Conservation: Common in Water Board catchments on Woronora Plateau. Limited examples in Royal NP (Keith unpubl. data), on Lambert Peninsula in Ku-ring-gai Chase NP (Buchanan 1980) and around Kariang (part of community 12 of Benson & Fallding 1981).

– SL Sedgeland

Sites: S2,S5,S7,S20,S27,S29,S30,S33,S41,S43,S50,S56,S59.

Habitat: Seepage slopes perched on sandstone benches or on the sides of large upland swamps. Soils are sandy, humic sandy loams.

Distribution: Small patches mainly in the eastern part of the catchment. Sedgeland occupies about 10% of the Heath-Sedgeland Mosaic (860 ha, 9.1% of study area).

Shrubs: 0.9 m tall, 29% cover; *Sprengelia incarnata*, *Bauera microphylla*, *Symphionema paludosum*, *Baeckea imbricata* and *Boronia parviflora* are characteristic of this community. Other common taxa include *Epacris obtusifolia* and *Almaleea paludosa*.

Groundcover: 0.6 m tall, 69% cover; *Lepidosperma filiforme* and *Schoenus paludosum* are characteristic. Other common taxa include *Ptilanthelium deustum*, *Leptocarpus tenax*, *Lepyrodia scariosa*, *Schoenus brevifolius*, *Cassytha glabella*, *Entolasia stricta*, *Drosera spathulata*, *Goodenia dimorpha* var. *angustifolia*, *Stylidium lineare*, *Xyris operculata*, *Empodisma minus* and *Chorizandra sphaerocephala*.

Disturbance: No obvious disturbance.

Conservation: Very localised on the Woronora Plateau. Representation within Royal NP is likely to be very limited.

– CH Cyperoid Heath

Sites: S1,S10,S11,S12,S13,S19,S25,S26,S28,S34,S40,S42,S45,S49,S57,S58

Habitat: Periodically waterlogged seepage zones in upland swamps. Soils are moderately deep gleyed organic sands and sandy loams.

Distribution: Southern and eastern parts of the catchment. Cyperoid Heath occupies about 30% of the Heath-Sedgeland Mosaic (860 ha, 9.1% of study area).

Shrubs: 1.4 m tall, 34% cover; Characteristic taxa include *Banksia robur*, *Hakea teretifolia* (multi-stemmed form), *Leptospermum juniperinum*, *Almaleea paludosa* and *Epacris obtusifolia*.

Groundcover: 1.0 m tall, 86% cover; characteristic taxa include *Lepidosperma limicola*, *Gymnoschoenus sphaerocephalus*, *Selaginella uliginosa* and *Xyris ustulata*. Other common taxa include *Xyris operculata*, *Tetrarrhena turfosa*, *Baumea teretifolia*, *Chorizandra sphaerocephala*, *Empodisma minus*, *Leptocarpus tenax*, *Schoenus brevifolius*, *Entolasia stricta* and *Xanthorrhoea resinifera*.

Disturbance: Small patches excavated for clay extraction, otherwise undisturbed.

Conservation: Most common on eastern Woronora Plateau in Water Board catchments. Limited examples in Royal NP (Keith unpubl. data), on Lambert Peninsula in Ku-ring-gai Chase NP (Buchanan 1980) and around Kariang (part of community 12 of Benson & Fallding 1981).

TT Ti-Tree Thicket

Sites: S15,S16,S21,S23,S24,S35,S46,S54,S60.

Habitat: Waterlogged drainage lines in large upland swamps. Soils are deep, highly organic gleyed loams and clay loams.

Distribution: 51 ha (0.5% of study area). Scattered in southern and eastern parts of the catchment.

Shrubs: 2.5 m tall, 37% cover; Characteristic taxa include *Leptospermum juniperinum*, *L. grandifolium*, *Epacris paludosa*, *Banksia robur*, *Melaleuca squarrosa*, *Viminaria juncea* and *Acacia rubida*.

Groundcover: 1.6 m tall, 90% cover; *Gleichenia microphylla*, *G. dicarpa*, *Gahnia sieberiana*, *Lepyrodia anarthria* and *Baumea teretifolia* are characteristic. Other common taxa include *Chorizandra sphaerocephala*, *Empodisma minus* and *Tetrarrhena turfosa*.

Variability: The shrub stratum varies from dense to almost absent, depending on water table fluctuation and long-term fire history.

Disturbance: No obvious disturbance.

Conservation: Most common on eastern Woronora Plateau in Water Board catchments. Limited examples in Royal NP (Keith unpubl. data) and on Lambert Peninsula in Ku-ring-gai Chase NP (Buchanan 1980).

[illegible]

<i>Leucopogon ericoides</i>	11-11----	--1--1--	-----	---	-1-	--	-1-
<i>Lissanthe strigosa</i>	1---11---	-----	-----	---	-1-	--	-
<i>Xanthorrhoea concava</i>	-1-1-1--	-----	-----	---	---	--	-
<i>Eragrostis brownii</i>	---1-----	-----	-----	1	---	--	-
<i>Cheilanthes sieberi</i>	---1-----	-----	-----	-----	---	--	-
<i>Dodonaea triquetra</i>	--1333-3	1----1--	--2-3	-----	---	--	-
<i>Eucalyptus punctata</i>	--3433-3	-----	-----	-----	---	--	-
<i>Exocarpos strictus</i>	---113--	-----	-----	-----	---	--	-
<i>Eucalyptus pilularis</i>	---33---	-----	-----	-----	---	--	-
<i>Cheilanthes distans</i>	-----1-	-----	-----	-----	---	--	-
<i>Danthonia longifolia</i>	---4-----	-----	-----	---	---	--	1
<i>Banksia marginata</i>	--1-----	-----	-----	-----	-1	--	-1
<i>Conospermum longifolium</i>	---1-----	-----	-----	-----	1-1-	--	-1
<i>Schoenus ericetorum</i>	--1-----	-----	-----	1	---	--	-1
<i>Grevillea sphacelata</i>	-1-----	-----	-----	-----	1112-	--	-1
<i>Caustis flexuosa</i>	2--211112	1--222-1	-1-----	-----	2111-1	--	-
<i>Dillwynia retorta</i>	33311-111	-211-2-1	-----	1	---	--	-1
<i>Leptospermum trinervium</i> (nl)	-331132-1	-11211-2	--12-	---	1421-	--	-2
<i>Grevillea buxifolia</i>	--11-----	-----	-----	---	-1-	--	-
<i>Melichrus urceolatus</i>	-----	-----	-----	---	-1-	--	-
<i>Grevillea diffusa diffusa</i>	3-1-1----	2--12--	1-----	---	-11-	--	-1
<i>Lomandra filiformis filiformis</i>	1-----	-----	11--	---	-1-	--	-
<i>Eucalyptus multicaulis</i>	--31-----	-----	-----	---	---	--	-
<i>Petrophile sessilis</i>	1332-----	-----	-----	---	-11-21	--	-1
<i>Hakea sericea</i>	1132-1-1	2-1-1---	-----1	-1-	111-1-	--	-2
<i>Bossiaea obcordata</i>	-----1-	-----	-----	---	-12-11	--	-
<i>Eucalyptus oblonga</i>	-----	-----	-----	21--	222-12	--	-1
<i>Mirbelia speciosa</i>	3-3-1----	-----	-----	-1-	111----	--	-1
<i>Schoenus turbinatus</i>	-----	-----	-----	-1-	11----	--	-
<i>Boronia ledifolia</i>	--2-1-1-	-----	-----	---	1-----	--	-

<i>Patersonia glabrata</i>	---	113--	-----	--1	111-1111	1--	-	22-2	1-1-1	11-1-1	11	121	-----
<i>Telopea speciosissima</i>	---	11--	-----	-----	---11-	-----	-----	11--	-----	1-----	--	-----	-----
<i>Aotus ericoides</i>	---	-----	-----	-----	22123-1-	-----	-----	-----	1-1--	-----1	--	-----	-----
<i>Eucalyptus piperita</i>	233-23--	-----	-1-----	-----	33333333	22-----	-----	-----	-----	-----	--	1--	-----
<i>Empodisma minus</i>	-----	-----	-----	-----	111-----	-----	-----	-----	-1--	-----	--	-----	-1-----
<i>Gleichenia dicarpa</i>	-----	-----	-----	-----	11-----	-----	-----	-----	-----	-----	--	-----	-----
<i>Exocarpos cupressiformis</i>	-----	-----	-----	-----	-1-----	-----	-----	-----	-----	-----	--	-----	-----
<i>Gonocarpus teucrioides</i>	-----	1--	1--2-----	-----	11111-2-	1-1----	-----	---1	-1--	-----1	--	-----	-----
<i>Smilax glyciphylla</i>	1-1-1--	-----	-1-----	-----	1111111-	112----	-----	---1	-11-	-----	--	-----	-----
<i>Cassytha pubescens</i>	-----	1--	112-----	-----	1111-11-	-12----	-----	11--	-----	-11-1	--	-----	-1-----
<i>Zieria laevigata</i>	-----	-----	-----	-----	111--11-	-1-----	-----	-----	-----	-----	--	-----	-1-----
<i>Gahnia radula</i>	-----	-----	-----	-----	1-----1-	-----	-----	-----	-----	-----	--	-----	-----
<i>Lomandra gracilis</i>	-1-1-1-	-----	---2-1-	-----	1111-11-	-----	-----	-----	-11-	-1----	--	-----	-----
<i>Tetrarrhena turfosa</i>	-11-2--	-----	-----	-----	1--1-11-	-1-----	-----	---1	-1--	-----	--	-----	-----
<i>Lomandra cylindrica</i>	-----	-----	12--1-1-	-----	1-----111	-----	-----	-1--	1----	-----1	1-	-1	-1-----
<i>Isopogon anethifolius</i>	-----	-----	-----	-----	1-----	-----	-----	-----	-----	-----	1-	-----	-----
<i>Styphelia tubiflora</i>	-----	-----	-----	-----	1-----	-----	-----	-----	-----	-----	--	-----	-----
<i>Wahlenbergia gracilis</i>	-----	-----	-----	-----	1-----	-----	-----	-----	-----	-----	--	-----	-----
<i>Pultenaea scabra</i>	-----	-----	2-----	-----	1-1-----	-----	-----	---1	-----	-----	--	-----	-----
<i>Hibbertia monogyna</i>	-----	-----	-----	-----	2-11-1-1	-----	-----	-----	1----	-----	--	-----	-----
<i>Woollisia pungens</i>	-----	-----	-----	-----	-11-1-	-----	-----	-----	-----	-1----	--	-----	-----
<i>Styidium productum</i>	-----	-----	-----	-----	-1--1-	-----	-----	-----	-----	-----	--	-----	-----
<i>Tetradlea shiressii</i>	-----	-----	-----	-----	-1-----	-----	-----	-----	-----	-----	--	-----	-----
<i>Schizea bifida</i>	-----	-----	-----	-----	-1-----	-----	-----	-----	-----	-----	-1	-----	-----
<i>Lomandra filiformis coriacea</i>	-----	1-1-	---1----	-----	-----1-1	-----	-----	1-1-	1----	-----1	--	-----	-----
<i>Thysanotus tuberosus</i>	-----	-----	-----	-----	-----1-1	-----	-----	-----	-----	-1--1	--	-----	-----
<i>Chloanthes stoechardis</i>	-----	-----	-----	-----	-----1-1	-----	-----	-----	-----	-----	--	-----	-----
<i>Choretrum candollei</i>	-----	-----	-----	-----	-----1-1	-----	-----	-----	-----	-----	--	-----	-----
<i>Bauera rubioides</i>	-----	-----	-----	-----	---11-1-	1--111	-----	-----	-----	-----	--	-----	-----
<i>Gleichenia microphylla</i>	-----	-----	-----	-----	---1-1-1-	1--2-2	-----	-----	-----	-----	--	-----	-----

<i>Leptospermum morrissonii</i>	---	---	---	---	---	1-2413	---	---	---
<i>Pseudanthus pimelioides</i>	---	---	---	---	---	-13-1	---	---	---
<i>Tristaniopsis laurina</i>	---	---	---	---	---	-43-1	---	---	---
<i>Lomandra fluviatilis</i>	---	---	---	---	---	-232-	---	---	---
<i>Tristania neriiifolia</i>	---	---	---	---	---	1-324-	---	---	---
<i>Phebalium dentatum</i>	---	---	---	---	---	-111-	---	---	---
<i>Lomatia myricoides</i>	---	---	---	---	---	3-3221	---	1-	---
<i>Sticherus flabellatus</i>	2-	---	---	---	---	3-311-	---	---	---
<i>Micrantheum hexandrum</i>	---	---	---	---	---	-31-4	---	---	---
<i>Restio dimorpha</i>	---	---	---	---	---	-21-2	---	-2	---
<i>Stenocarpus salignus</i>	---	---	---	---	---	-3---	---	---	---
<i>Bossiaea rhombifolia</i>	---	---	---	---	---	-2-	---	---	---
<i>Allocasuarina littoralis</i>	1-	---	---	41	1-1-1-	-23-	---	---	---
<i>Ceratopetalum apetalum</i>	---	---	---	---	---	4131-1	---	---	---
<i>Phebalium squamulosum</i>	---	---	---	---	---	211--1	---	---	---
<i>squamulosum</i>	---	---	---	---	---	---	---	---	---
<i>Hibbertia nitida</i>	---	---	---	---	--1-	1-1--1	---	---	---
<i>Prostanthera linearis</i>	---	---	---	---	---	1-2--1	---	---	---
<i>Acacia irrorata</i>	---	---	---	---	---	-1--1	---	---	---
<i>Grevillea longifolia</i>	---	---	---	---	---	-1--1	---	---	---
<i>Pomaderris intermedia</i>	---	---	---	---	1--	-11--2	---	---	---
<i>Pomaderris andromedifolia</i>	---	---	---	---	---	-1--	---	---	---
<i>Backhousia myrtifolia</i>	---	---	---	---	---	-11--	---	---	---
<i>Lasiopetalum ferrugineum</i>	---	---	---	---	-1----	-1	---	---	---
<i>Bertya pomaderroides</i>	---	---	---	---	---	-1--1	---	---	---
<i>Gonocarpus microphyllus</i>	---	---	---	---	---	-1--1	---	---	---
<i>Chorizandra cymbaria</i>	---	---	---	---	---	-1--1	---	---	---
<i>Westringia longifolia</i>	---	---	---	---	---	-1--1	---	---	---
<i>Callistemon citrinus</i>	---	---	---	---	---	-1--1	---	---	---
<i>Leptospermum polygalifolium</i>	--1----	---	---	---	--1--1-	1-----1	---	-1-1	---

<i>Acacia myrtifolia</i>	----	111-	----	1-1-1-1-	----	3212	----	2-1-11	--	11-	----	1
<i>Eucalyptus gummiifera</i>	---	32322	32332-3--	-131--22	----	2343	34123	13233	--	122	11----	
<i>Eucalyptus racemosa</i>	-----	-----	-----	-----	-----	2332	2-----	23--33	--	1--	1-----	
<i>Eucalyptus sieberi</i>	-----	1--	-----	-121--1	-----	3333	3-----	3-----	--	-1-	-----	
<i>Lobelia dentata</i>	-----	-----	-----	-----	-----	-----	1-----	-----2-	--	-----	-----	
<i>Stipa pubescens</i>	---	112--	112--	-----1-	-----	11-1	-----	-1--21	--	-----	-----	
<i>Haemadorum planifolium</i>	-----	-----	-----	-----	-----	-1-	1-----	-----1-	--	-----	-----	
<i>Viola sieberiana</i>	-----	-----	-----	-----	-----	-1-	-----	-----	--	-----	-----	
<i>Mitrasacme polymorpha</i>	-----	-----	-----	-----	-----	-1-	11----	-----11	1-	111	-----	
<i>Scaevola ramosissima</i>	---	-----	-----	-----1-	-----	1-1-	111-1	-----11	11	-1-	-----	
<i>Hypericum gramineum</i>	---	1--11	-----	-----	-----	-----	-----	-----1-	--	-----	-----	
<i>Deyeuxia decipiens</i>	-----	-----1	-----	-----	-----	-----	-----	-----1-	--	-----	-----	
<i>Opercularia varia</i>	---	-----11	-----	-----	-----	-1-	-----	-----2-	--	-----	-----	
<i>Pelargonium inodorum</i>	-----	-----	-----	-----	-----	-----	-----	-----1-	--	-----	-----	
<i>Caesia vittata</i>	-----	-----	-----	-----	-----	-----	-----	-----1-	--	-----	-----	
<i>Leucopogon virgatus</i>	-----	-----	-----	-----	-----	-----	-----	-----1-	--	-----	-----	
<i>Caesia parviflora</i>	-----	-----	-----	-----	-----	-----	-----	-----1	--	1-1	-----	
<i>Hakea teretifolia</i> (ss)	---	-----1-	-----	-1-----	-----	-1-	11----	-----1	--	1-1	1-----	
<i>Goodenia dimorpha</i>	-----	-----	-----	-----	-----	-----	-----	-----1	--	-----	-----	
<i>angustifolia</i>	-----	-----	-----	-----	-----	-----	-----	-----	--	-----	-----	
<i>Genoplesium nublilingii</i>	-----	-----	-----	-----	-----	-----	-----	-----1	--	-----	-----	
<i>Hybanthus monopetalus</i>	-----	-----	-----	-1--1-	-----	-1-	-----	-1--1	--	11-	-----	
<i>Sphaerolobium vimineum</i>	-----	-----	-----	-----	-----	-----	-1--	-1--1	--	11-	1-----	
<i>Platysace ericoides</i>	---	-----1-	-----	-----	-----	-----	-11--	11-122	11	1--	--1-	
<i>Thelymitra circumsepta</i>	-----	-----	-----	-----	-----	-----	-----	-----11	-1	-----	-----	
<i>Tricoryne simplex</i>	-----	-----	-----	-----	-----	-----	-----	-----11	-1	1--	-----	
<i>Acacia suaveolens</i>	-----	-----	-----1-	11-----1	-----	11--	11111	11-11-	11	1-1	11----	
<i>Dampiera stricta</i>	---	-----11	1-----	-1--11-	-----	1211	11111	11111	11	111	1-----	
<i>Lomandra glauca</i>	-----	-----	-----1-	-1--1-	-----	12--	11111	1112-1	11	-11	--1-	
<i>Xyris gracilis laxa</i>	-----	-----	-----	-----	-----	-1-	11111	11--1	11	111	-----	

[illegible]

<i>Drosera peltata</i>	----	1--	--11	----	----	----	--11-	-1--1-	11	111	-1----
<i>Baeckea brevifolia</i>	----	----	----	----	----	----	----	----	-1	11-	----
<i>Burchardia umbellata</i>	----	----	----	----	----	----	----	----	11	11-	----
<i>Sowerbaea juncea</i>	----	----	----	----	----	----	----	----	11	11-	----
<i>Pultenaea elliptica</i> (rf)	----	----	----	----	----	----	----	----	13	11-	----
<i>Blandfordia nobilis</i>	----	----	----	----	----	----	----	----	11	1-1	----
<i>Conospermum taxifolium</i>	----	----	----	----	----	----	----	----	11	1--	----
<i>Hibbertia serpyllifolia</i>	----	----	1--	----	----	----	----	----	22	21-	----
<i>Schoenus pachylepis</i>	----	----	----	----	----	----	----	----	22	211	----
<i>Restio gracilis</i>	----	----	----	----	----	----	----	----	1-	1--	----
<i>Stackhousia viminea</i>	----	----	----	----	----	----	----	----	--	1--	----
<i>Conospermum tenuifolium</i>	----	----	----	----	----	----	----	----	--	1--	----
<i>Xyris juncea</i>	----	----	----	----	----	----	----	----	--	1--	----
<i>Angophora hispida</i>	----	----	----	----	----	----	----	----	33	----	----
<i>Brachyloma daphnoides</i>	----	----	----	----	----	----	----	----	11	----	----
<i>Kunzea capitata</i>	----	----	----	----	----	----	----	----	32	1-2	3----
<i>Lepidosperma neesii</i>	----	----	----	----	----	----	----	----	1-	1--	2----
<i>Grevillea parviflora</i>	----	----	----	----	----	----	----	----	1-	----	1----
<i>Hypoxis hygrometrica</i>	----	----	----	----	----	----	----	----	1-	----	----
<i>Stylidium lineare</i>	----	----	----	----	----	----	----	----	--	-1	1----
<i>Thelonema caespitosum</i>	----	----	----	----	----	----	----	----	--	-1	----
<i>Sprengelia incarnata</i>	----	----	----	----	----	----	----	----	--	-1	----
<i>Stackhousia nuda</i>	----	----	----	----	----	----	----	----	--	-1	----
<i>Orthoceras strictum</i>	----	----	----	----	----	----	----	----	--	-1	----
<i>Aristida warburgii</i>	----	----	----	----	----	----	----	----	--	-1	----
<i>Dillwynia floribunda</i>	----	----	----	----	----	----	----	----	--	-1	----
<i>Leptocarpus tenax</i>	----	----	----	----	----	----	----	----	--	-1	1----
<i>Lepidosperma squamatum</i>	----	----	----	----	----	----	----	----	--	312	----
<i>Actinotus helianthi</i>	----	----	----	----	----	----	----	----	--	----	----
<i>Pseudanthus orientalis</i>	----	----	----	----	----	----	----	----	--	----	----
<i>Styphelia triflora</i>	----	----	----	----	----	----	----	----	--	----	----

Performance of halophytes from semi-arid areas on two saline seepage scalds of the Central Western Slopes of NSW

W.S. Semple and D. Waterhouse

Semple, W.S.¹ & Waterhouse, D.² (Soil Conservation Service of NSW, ¹PO Box 53 Orange 2800; ²PO Box 445 Cowra 2794). Performance of halophytes from semi-arid areas on two saline seepage scalds of the Central Western Slopes of NSW. *Cunninghamia* 3(3): 595–608. Typical halophyte genera from western and coastal NSW are largely absent from saline sites in the central west. Possible reasons for this include climatic and soil differences, relative newness of the central western saline sites and the lack of appropriate dispersal mechanisms. The last mentioned was overcome in this trial by deliberately introducing propagules from semi-arid areas to saline scalds at two sites in the central west. The combined effects of straw mulching and exclosure resulted in the establishment of a number of western species. Two annuals, *Mesembryanthemum nodiflorum* and *Frankenia pulverulenta*, were particularly well adapted. Perennial species of Chenopodiaceae, Frankeniaceae and Zygophyllaceae also established but were slower to colonise. Although propagule availability to both central western sites was similar, there were significant differences in species establishment at the two sites. There were also differences in the occurrence of native/naturalised species between the two sites. Chemical differences between the soils at the two sites were suggested as the reason for this.

Introduction

Recent land degradation mapping* in the Upper Murray–Darling Basin shows that saline sites are widespread on the central west of NSW. 'Seepage scalds', bare eroded areas where a saline watertable is close to or at the surface (Williams & Bullock 1989), are usually present at sites with advanced salinisation. Electrical conductivities (EC_e , estimated from $EC_{1:5 \text{ soil:water}}$) of 0–5 cm soil samples from a selection of central western scalds ranged from 12 to 56 dSm⁻¹ (Hamilton 1972) and in a more recent survey, from 15 to 87 dSm⁻¹ (Semple 1993).

According to a Victorian classification of degree of salinisation, many of these sites are 'severely affected' and would be expected to support a sparse cover of halophytes, e.g. *Disphyma crassifolium** (Aizoaceae) and species of Chenopodiaceae such as *Sarcocornia*, *Suaeda* or *Halosarcia* (Matters & Bozon 1989). A botanic survey of 21 saline sites in part of the central west of NSW (including the western fall of the Great Dividing Range and extending west to Cowra, Manildra, Dubbo and Dunedoo) found no such halophytes (Semple 1993). Though seepage scalds were largely bare, the most common species present were the grasses, *Critesion maritimum*, *Cynodon dactylon*, *Parapholis incurva*, *Polypogon monspeliensis* and the annual forb, *Spergularia marina*, all of which Matters & Bozon (1989) considered typical of 'moderately salted' sites.

* Unpublished. Prepared at a scale of 1:100 000 for the Upper Macquarie and Lachlan River catchments by the Soil Conservation Service of NSW.

* Nomenclature in this paper follows Jacobs & Pickard (1981) except where updated by the *Flora of NSW* Vols. 1 (1990), 2 (1991) & Wheeler et al. (1990).

Apart from Poaceae (which contains many salt-tolerant species), Aizoaceae, Frankeniaceae and Chenopodiaceae are major sources of halophytes. None of these families is well represented in the flora of the Central Western Slopes botanic subdivision and even less so on saline sites in the eastern part of the subdivision. Of the 52 species from these families noted as native or naturalised on saline sites (Table 1), 37 are restricted to the Western and/or Far Western Plains botanic divisions and 7 to the Coastal division. Only 6, *Glinus lotoides*, *Tetragonia tetragonioides* (Aizoaceae), *Enchylaena tomentosa*, *Atriplex suberecta*, *A. semibaccata* (Chenopodiaceae) and *Frankenia serpyllifolia* (Frankeniaceae) have a range extending to the Central Western Slopes subdivision. Apart from *A. semibaccata*, none of these species was recorded on or near saline sites in the east of this division by Semple (1993). In a survey of part of the Southern Tablelands, which included saline sites, no plants from these three families were recorded (Kodala & Foster 1990).

The reasons for the lack of coastal, arid and semi-arid forbs and subshrubs on seepage scalds of the central west are unclear, but could include:

- the temperate climate with its frequent frosts and at times, abundant run-on water
- the presence of a continually higher watertable, i.e. 'wet' rather than 'dry' scalds
- the presence of a pre-existing, at least partly adapted, grassy flora on favourable microsites on the scalds
- regular fluctuation in salinity levels — primarily because of rainfall (Logan 1958)
- the generally higher pH and carbonate and/or sulphate contents in western soils (Lawrie 1991) compared to those of the central west.

These potentially adverse effects would primarily affect germination and early establishment. For example, some species are salt sensitive during germination but less so later on and vice versa (Logan 1958). The successful introduction of tubestock of *Atriplex nummularia* (old man saltbush) to seepage scalds of the central west in recent years shows that plants of semi-arid areas can flourish in this environment.

Table 1. Number of taxa from the main dicotyledonous halophyte-containing families recorded as native or naturalised in NSW and the Central Western Slopes (CWS) botanic subdivision.

Family	No. of taxa recorded in:			No. of taxa noted to occur in saline habitats*
	NSW#	CWS#	Eastern CWS saline sites [▼]	
Aizoaceae	32	7	0	13
Chenopodiaceae (excluding <i>Chenopodium</i> *)	164	24	4	33
Frankeniaceae	11	1	0	6

From Jacobs & Highet (1990), Jacobs (1990) and Miller (1990).

▼ From Semple (1993).

* Determined from habitat data recorded by the above authors as well as by Cunningham et al. (1981), Matters & Bozon (1989), Clarke (1989) and Runciman & Malcolm (1989). This approach underestimates the number of halophytes, as detailed habitat data was not always available, or was of the form 'occurs in a wide range of habitats'. Also, as many soils of the western plains are naturally saline, e.g. scalds and desert loams (Lawrie 1991), salinity would not warrant particular mention in a habitat description.

• A ubiquitous genus in NSW with no noted halophytes.

However, to the authors' knowledge, this species has not been established from seed, nor has recruitment occurred, on scalds in this region.

A likely reason for the absence of halophytes from more remote botanical subdivisions is the lack of opportunity. This involves changes to the environment, or 'disturbance' (Amor & Piggin 1977), and availability of seed, which depends on dispersal mechanisms, seed longevity and time. It is not known when salinisation first became evident in the central west, but it presumably followed a similar pattern to that reported by Wagner (1957 p.33) in the Goulburn area: 'The condition [salt accumulation and concentration], although previously present to a small extent, first became manifest to a serious degree in this district following the unusually wet seasons of 1950-51-52.' At least one saline site near Manildra has been known since the 1920s (B. Wild, pers. comm.).

Saline habitats are not continuous in space in either the Coast or Western Plains divisions. If disturbance (salinisation) is a geologically recent phenomenon, it is not surprising that the variety of halophytes in the central west is low. The opportunity for seed dispersal by vehicles (e.g. Wace 1977) is low as saline sites are localised and visited mainly by farm vehicles, which would be unlikely to have travelled to other divisions. Similarly, dispersal by domestic livestock also would be unlikely due to the general lack of stock movement (apart from in transit) between the central west and either the coast or western NSW.

The aim of the trial described below was to artificially overcome dispersal problems and deliberately introduce propagules of plant material from western NSW to severely salinised sites in the central west.

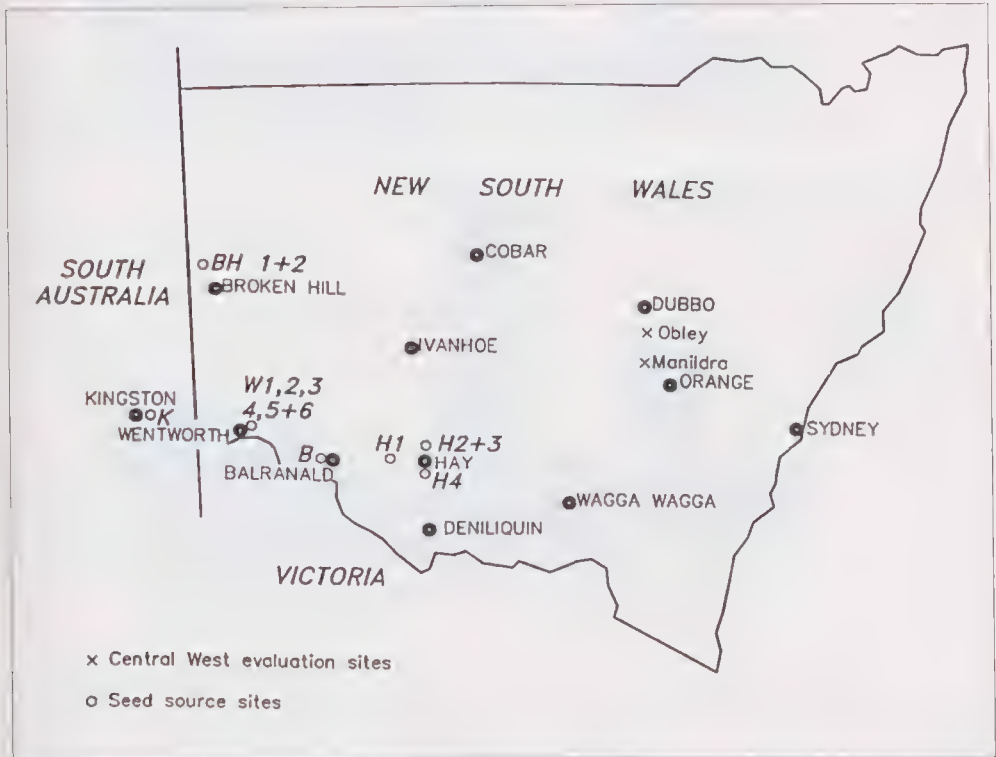


Figure 1. Location of experimental sites and sources of western plant material.

Methods

Several sites were examined and two were selected based on accessibility, apparent uniformity of unvegetated scald surface and consent/interest of the landowner. Site descriptions are provided in Table 2, locations in Figure 1 and rainfall data for Dubbo (40 km north of the Obley site) and Manildra (10 km east of the Manildra site) in Figure 2.

Introduced plant material did not generally consist of specific seed collections. Instead, litter and soil surface ‘scrapings’ were collected from 13 western NSW sites

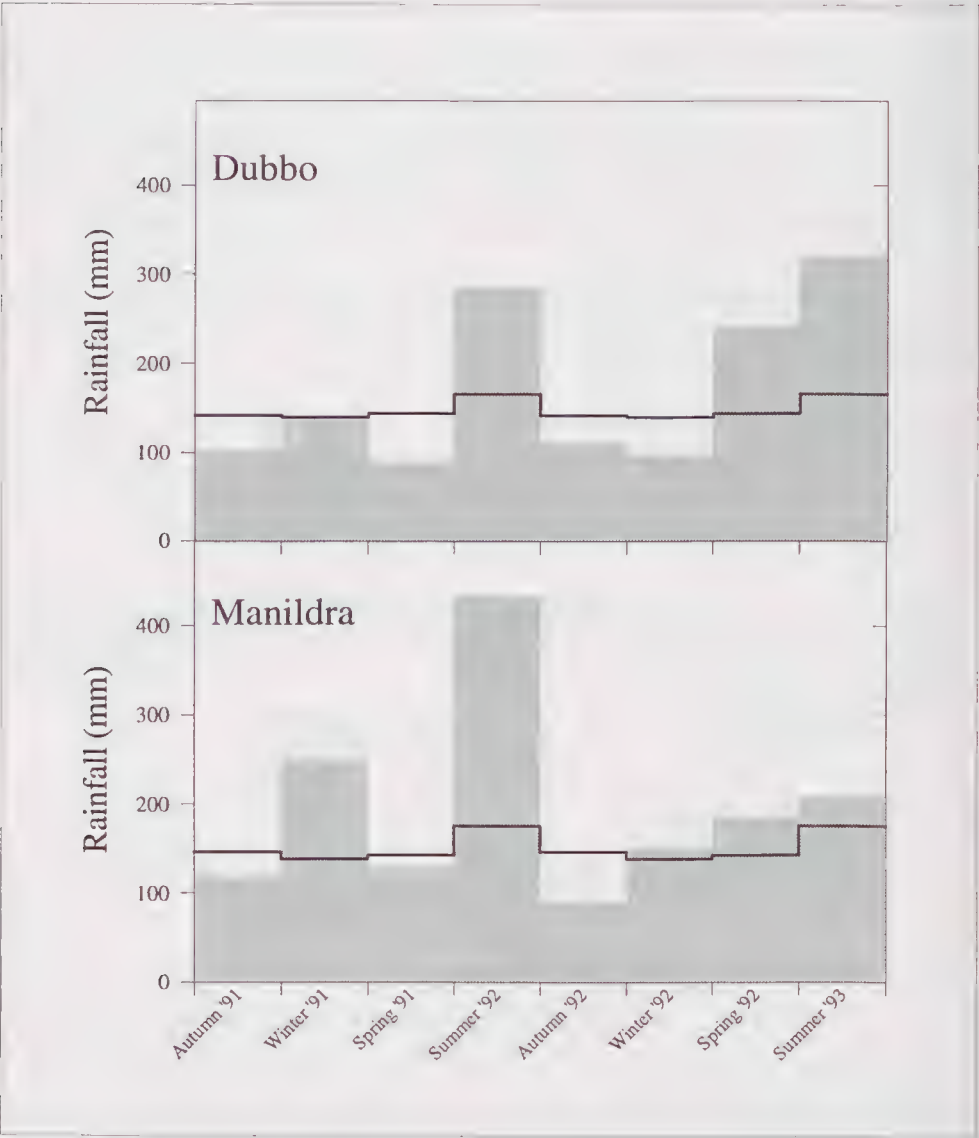


Figure 2. Comparison of autumn 1991 to summer 1993 rainfall and the long-term seasonal average (—) recorded at Dubbo and Manildra.

and one South Australian site (Figure 1) by the authors and other Soil Conservation Service staff during the summer of 1990–91. This procedure meant that the seed composition of the sample was largely unknown. Apparent salinity of the source sites was rated between 'nil' (i.e. naturally low salinity) to 'very saline'.

In addition to this material, seeds or fruits of five known salt-tolerant species and three selections of presumed tolerators were also sown (Table 3).

Trial design consisted of a randomised complete block of 20 (Manildra) and 24 (Obley) 0.25 x 0.25 m plots replicated three times. Each litter sample was split into subsamples (of about 200g, depending on amount of material available) and spread evenly on each of the three replicate plots. All plots were sprayed with a residual insecticide (permethrin at 2.5 g/L a.i.) to stop seed being taken by ants. Cereal straw, which earlier studies (e.g. Wagner 1957, Logan 1958, Hamilton 1972) had shown to be effective in promoting germination and establishment on saline sites, was then applied and held down with netting. Treatments and application rates are listed in Table 3.

The Manildra plots were surface-sown and herbivores were excluded with rabbit-proof netting on 27 March 1991, and the Obley plots received the same treatment on 19 April 1991. Sites were visited at regular intervals spanning four growing seasons (2 x autumn–winter and 2 x spring–summer) to record species present in each plot and on the scald within the enclosure. Known undesirable species, e.g. *Xanthium spinosum*, were recorded and later removed.

Table 2. Descriptions of experimental sites

Obley:	20 km north of Obley; adjacent to Paddy's Creek.
Elevation:	350 m.
Topography:	Footslope with saline seepages.
Soil:	Eroded duplex soil with lag gravel, rills, shallow gullies, scalds and hummocks of remnant topsoil. Localised organic (black) staining and on the upper slopes outcrops of calcrete. Within the enclosure the scald's surface is 'puffy' when dry.
Vegetation:	Scattered <i>Eucalyptus microcarpa</i> and clumps of <i>Allocasuarina leuhmannii</i> with an under storey dominated by <i>Stipa scabra</i> , <i>Danthonia</i> spp. and annuals. Scalds support very scattered <i>Cynodon dactylon</i> , <i>Critesion marinum</i> , <i>Parapholis incurva</i> and <i>Spergularia marina</i> .
Age of site:	The landowner reported that the site has been bare as long as he and his late father could remember.
Manildra:	10 km west of Manildra; adjacent to Manildra Creek.
Elevation:	490 m.
Topography:	Footslope with saline seepages.
Soil:	Eroded duplex soil with rills, shallow gullies, scalds and very low hummocks of remnant topsoil. Localised lag gravel.
Vegetation:	Treeless with scattered <i>Eucalyptus microcarpa</i> on the margins. Annual grassland with species of <i>Lolium</i> , <i>Bromus</i> , <i>Critesion</i> and <i>Trifolium</i> . Scalds support scattered <i>Parapholis incurva</i> , <i>Critesion marinum</i> , <i>Cynodon dactylon</i> and <i>Polypogon monspeliensis</i> .
Age of site:	The paddock containing the site has been known as 'Salt paddock' for as long as a nearby landholder could remember (c. 60 yrs).

As an indicator of species adaptability to each site, two measures were employed:

- The frequency of occurrence of a species in all plots. This reflects the combination of both seed initially present and the colonising ability of the seed. Changes in frequency between year 1 and year 2 are further indicators of species adaptability to a site.
- The presence of an individual species outside the plots into which it was originally sown, i.e. on bare scald or in mulch-only plots.

Results

During the two-year period, 36 vascular plant species were recorded in the Obley enclosure and 30 at Manildra — representing a total of 48 species, though some were recorded only once or consistently in only one plot. Many of these (20/36 at Obley and 14/30 at Manildra) were already native or naturalised near the experimental site (as well as on the Western Plains).

Species frequencies of occurrence in all plots at each site during years 1 and 2 are shown in Tables 4, 5 and 6. Species which occurred in new habitats (the unmulched scald or unseeded mulch) are shown in Table 7.

The occurrence of some species at one experimental site but not the other prompted a more detailed examination of the soil properties at each site. Analyses of the soils at the experimental sites, together with some Wentworth sites (which represented the largest number of source sites for introduced species) are presented in Table 8.

Discussion

The technique of establishing plants from 'litter' samples placed below straw mulch was successful with many semi-arid species. It was less successful with the known seed introductions. Straw mulch also provided an establishment medium for native/naturalised species, which generally increased in frequency with time. Very few species had the ability to colonise bare scald, despite the lack of grazing.

Annual species

The results indicate that a number of species from semi-arid areas are adapted to saline scalds of the central west — albeit under mulched and ungrazed conditions. As expected in a trial of short duration, annuals were the most common. Of these, large increases in frequency were recorded for *Schismus barbatus*, *Mesembryanthemum nodiflorum*, *Frankenia pulverulenta* (Table 6). These species — all introductions to Australia — appear to be of little forage value (Cunningham et al. 1981), and may have weed potential.

Exclosure and mulching also favoured some native/naturalised species (Table 4). Frequency of occurrence of *Critesion marimum* and *Parapholis incurva* (both naturalised species in NSW) was comparable to that of the most common annuals introduced from farther west.

Many frequently occurring native/naturalised species listed in Table 4 are common on saline sites of the central west and are also found in western NSW. It is likely that many of the plants — particularly in the first year — originated from western 'litter' samples. Of the annuals not commonly associated with saline sites in the central west

Table 3. Treatments and seeding rates at Obley and Manildra
Treatment* and seeding rate

	Obley	Manildra
<i>Puccinellia ciliata</i> cv. Menemen 32kg/ha	+	+
<i>Thinopyrum elongatum</i> 64kg/ha	+	+
<i>Chloris truncata</i> , selection 291 40kg/ha	+	+
<i>Chloris truncata</i> , selection 191 40kg/ha	+	+
<i>Enteropogon ramosus</i> , selection 391 40kg/ha	+	+
<i>Trifolium fragiferum</i> cv. Palestine (inoculated) 16kg/ha	+	+
<i>Atriplex nummularia</i> 32kg fruits/ha	+	–
<i>Maireana brevifolia</i> 32kg fruits/ha	+	–
Western NSW/SA litter samples from all sites except BH 1 & 2	+	+
Western NSW litter samples from (Broken Hill) sites BH 1 & 2	+	–
Straw mulch only	+	+
Nil (no mulch or propagules)	+	+

* Except for the 'Nil' treatment, all were mulched with cereal straw at the rate of 8t/ha (Manildra) and 4t/ha (Obley).

Table 4. Frequency of occurrence of native/naturalised species at the experimental sites. Species with < 10% frequency in the second year have been excluded. All are annuals unless indicated by (P).

Species	Frequency of occurrence (%) in plots at each site			
	Obley		Manildra	
	year 1	year 2	year 1	year 2
<i>Bromus molliformis</i>	0	33	0	0
* <i>Chloris truncata</i> (P)	0	35	0	2
* <i>Critesion marinum</i>	60	86	35	57
* <i>Cynodon dactylon</i> (P)	0	4	0	22
* <i>Lolium</i> sp.	10	19	20	12
* <i>Parapholis incurva</i>	31	42	88	88
* <i>Polypogon monspeliensis</i>	0	0	12	10
<i>Sporobolus caroli</i> (P)	0	42	(0)#	(0)#
<i>Vulpia bromoides</i>	1	18	0	0
<i>Arctotheca calendula</i>	0	18	2	0
<i>Sonchus oleraceus</i>	1	0	7	13
* <i>Spergularia marina</i>	18	36	(0)#	(0)#
<i>Medicago</i> (all species combined)	7	44	8	10
<i>Polygonum aviculare</i> (P)	0	0	5	13

* A known tolerator of salinity in temperate areas (Matters & Bozon 1989, Semple 1993).

Not native/naturalised at this site.

Table 5. Frequency of occurrence of plants from introductions of known seed at the Obley and Manildra sites.

Species	Frequency (%) in plots in which it was sown				Frequency (%) in all plots			
	Obley		Manildra		Obley		Manildra	
	yr 1	yr 2	yr 1	yr 2	yr 1	yr 2	yr 1	yr 2
<i>Puccinellia ciliata</i>	100	100	100	100	24	15	33	60
<i>Thinopyrum elongatum</i>	0	0	0	67	0	0	0	3
# <i>Chloris truncata</i> (selections 291 & 191)	0	67	0	17	0	35	0	2
<i>Enteropogon ramosus</i>	0	0	0	0	0	0	0	0
<i>Trifolium fragiferum</i>	0	0	0	0	0	0	0	0
<i>Atriplex nummularia</i>	0	0	–	–	0	0	–	–
<i>Maireana brevifolia</i>	0	0	–	–	0	0	–	–

This species is native to both sites and western NSW. Plants may have originated from selected, naturally occurring or western seed.

– Not sown at this site.

(those without an * in Table 4), most were represented by stunted, poorly formed plants.

The introduced species, *Frankenia pulverulenta* and *Mesembryanthemum nodiflorum*, were more successful in establishing on bare scald than most of the native/naturalised annuals (Table 7). They also occurred on the scald outside the exclosures.

Perennial species

Perennial species, either native/naturalised or introduced in 'litter' samples, were well represented at both experimental sites. A number of the introduced species could not be identified until the second year and even then some had not seeded. Due to late or lack of seeding, the colonising ability of some of these species may not be known for some years.

Nine species of introduced perennial plants grew from 'litter' samples. Their capacity to colonise new plots was inhibited by late (year 2) or nil seeding; hence, frequencies were generally low (Table 6). Where an increase between years 1 and 2 occurred, it was likely that the plants were missed or recorded as 'unidentified' in year 1. Two species, *Sclerolaena muricata* var. *villosa* (though native at the Dubbo site) and *Tribulus terrestris*, were considered undesirable introductions, and plants were removed when observed.

Disphyma crassifolium subspecies *clavellatum*, *Osteocarpum acropterum*, *Halosarcia pergranulata*, *Sclerolaena brachyptera*, *S. muricata*, *Frankenia foliosa* and *Nitraria billardieri* comprised most of the introduced perennials. They are known tolerators of salinity or colonisers of dry scalds (Cunningham et al. 1981, Jacobs & Highet 1990, Miller 1990, Jacobs 1990).

Four native/naturalised perennial species were recorded within the exclosures and all increased in frequency between years 1 and 2 (Table 4). The species and their highest frequency of occurrence were *Sporobolus caroli* (42%), *Chloris truncata* (35%), *Cynodon dactylon* (22%) and *Polygonum aviculare* (13%). *P. aviculare* is usually considered a weed, whereas the others produce moderate to high quality forage. *S. caroli* and *C. truncata* are known colonisers of eroded areas (Cunningham et al. 1981). All of the grasses were recorded on bare scald, though the stolons of *C. dactylon* did not extend very far from their origin in a more favourable niche (Table 7).

With the exception of *Puccinellia ciliata*, establishment of perennials from deliberately introduced seed was low (Table 5). *P. ciliata* established in all plots where seed was placed and, following seeding in the first year, it spread to other plots. Its presence in the first year in plots other than those where it was sown indicated some transport of seed at the time of sowing. It had limited ability to colonise bare scald and was present only in a specialised niche, viz. some soil auger holes. *Thinopyrum elongatum* was represented by only a few plants in the second year at Manildra. The fate of the selections of *Chloris truncata* was difficult to determine as the species is native to both sites and also occurs in western NSW. It has been treated as a native/naturalised species in this discussion. *Trifolium fragiferum* did not establish at either site.

Source of semi-arid plant material

In Table 6 an attempt has been made to specify the seed source for the introduced semi-arid species. As would be expected, seed of some species appeared to be present in scrapings from more than one collection site. Wentworth (W) sites, which comprised 43% of all the source sites, accounted for 83% of first observations at Manildra.

All sites appeared to contribute species at Obley, though Wentworth sites were again common (50%).

The high representation of species from the Wentworth sites, prompted an investigation of soil properties at some of these sites. Analyses of soils from two sites (W2 and W4) are compared with the experimental sites in Table 8. Of the four soil analyses, the very high soluble salt concentration (as indicated by high EC), high pH, the high calcium: magnesium ratio of 23:1 (which suggests magnesium deficiency, Eckert 1987), and the high percentage of exchangeable sodium (indicating a strongly sodic soil, Pope & Abbot 1989), sets the Obley soil apart from the others. On soil chemistry alone, the Wentworth sites were more similar to Manildra (where Wentworth species were common) than to the Obley site.

Table 6. Frequency of occurrence and possible source of species introduced in 'litter' samples from semi-arid and arid areas. All are annuals unless indicated by (P).

Species	Frequency of occurrence (%) in plots at each site				Litter sources (site nos▼) for plants at	
	Obley		Manildra		Obley	Manildra*
	yr 1	yr 2	yr 1	yr 2		
POACEAE						
* <i>Lamarckia aurea</i>	6	3	0	0	BH1+2	—
* <i>Schismus barbatus</i>	8	57	0	0	W4, BH1	—
AIZOACEAE						
<i>Disphyma crassifolium</i> ssp. <i>clavellatum</i> (P)	0	13	2	2	H1+3, K, W3 W4+6	
* <i>Mesembryanthemum nodiflorum</i>	18	88	3	3	W1,2,3,4+5 W2	
* <i>Tetragonia tetragonioides</i>	0	14	0	0	B, W1, H2	—
					BH1+2	
ASTERACEAE						
<i>Pogonolepis muelleriana</i>	6	1	0	2	W4+6	W4
<i>Senecio glossanthus</i>	4	29	3	0	W4	W4
BRASSICACEAE						
<i>Menkea australis</i>	1	1	8	7	W4	W2, 3+4
CHENOPODIACEAE						
<i>Atriplex lindleyi</i>	1	3	2	2	B, W6	W4
<i>A. pumilio</i> (P)	3	4	0	0	W4	—
<i>Osteocarpum acropterum</i> var. <i>deminuta</i> (P)	0	3	0	0	W6	—
<i>Halosarcia pergranulata</i> (P)	0	0	10	15	—	W2+3
<i>Sclerolaena brachyptera</i> (P)	0	4	0	0	B, H4	—
<i>S. muricata</i> var. <i>villosa</i> (P)	0	(1)#	0	2	H2	H2
FRANKENIACEAE						
<i>Frankenia foliosa</i> (P)	0	0	0	7	—	W1+2
* <i>F. pulverulenta</i>	0	0	12	68	—	W2, 5+6
ZYGOPHYLLACEAE						
<i>Nitraria billardieri</i> ? (P)	0	0	3	3	—	B
<i>Tribulus terrestris</i> (P)	0	1	2	0	H2	H3
<i>Zygophyllum</i> sp.	0	1	0	0	W4	—

+ Litter samples from BH were not evaluated at Manildra.

▼ Key to sites is shown in Figure 1.

* Not native to Australia (Jacobs & Pickard 1991, Black 1952).

? Tentative identification as plants had not flowered.

Also native to this site.

Table 7. Occurrence of species in the 2nd year in new habitats following enclosure. All are annuals unless indicated by (P).

Site	Species	Bare scald		
		'Nil' plot	Between treatment blocks	Mulch-only plots
	Native and naturalised species			
Obley	<i>Bromus molliformis</i>	+	—	+
	<i>Chloris truncata</i> (P)	+	—	+
	<i>Critesion marinum</i>	+	—	+
	<i>Cynodon dactylon</i> (P)	—	+ ²	—
	<i>Lolium</i> sp.	—	—	+
	<i>Poa annua</i>	—	—	+
	<i>Parapholis incurva</i>	—	—	+
	<i>Sporobolus caroli</i>	—	+	+
	<i>Vulpia bromoides</i>	—	—	+
	<i>Arctotheca calendula</i>	—	—	+
	<i>Spergularia marina</i>	+	—	+
	<i>Medicago</i> spp.	—	—	+
Manildra	<i>Critesion marinum</i>	—	+ ¹	+
	<i>Cynodon dactylon</i> (P)	—	+ ²	—
	<i>Parapholis incurva</i>	+	+	+
	Introduced species			
Obley	<i>Puccinellia ciliata</i> (P)	—	+ ¹	—
	<i>Schismus barbatus</i>	+	—	+
	<i>Mesembryanthemum nodiflorum</i>	+	+	+
	<i>Senecio glossanthus</i>	—	—	+
Manildra	<i>Puccinellia ciliata</i> (P)	—	+ ¹	+
	<i>Frankenia pulverulenta</i>	+	+	+

+ = Present.

— = Absent.

¹ Specialised areas only such as auger holes or adjacent to rocks.² Mainly extension of stolons from more favourable habitats.**Table 8. Analyses of 0–10 cm soil samples from the Obley and Manildra experimental sites and two seed source sites near Wentworth**

	Obley	Manildra	Wentworth	
			W2	W4
pH 1:5 water	10.9	9.0	7.6	7.9
pH 1:5 0.01M Ca Cl ₂	10.6	8.8	7.3	7.4
EC 1:5 water (dSm ⁻¹)	4.73	1.24	1.26	0.75
EC _e estimated [#] (dSm ⁻¹)	45	8	29	10
Texture	silt loam	loamy sand	loamy sand	sandy loam
Phosphorus (Bray 2) (ppm)	50	27	38	25
Exchangeable Na percentage*	61.4	2.1	11.0	7.8
Ca	34.8	61.7	76.9	68.9
Mg	1.5	35.5	5.5	14.4
Ca/Mg	36.4	97.2	82.4	83.3

[#] After Slavich & Petterson (1993).

* As a proportion of exchangeable Na, K, Ca + Mg.

Table 9. Species that were restricted to one or other site (see text for exclusions). Frequency of occurrence in all plots in the second year is an indication of abundance at the site.

Site	Family	Species	Frequency (%)
Obley	Poaceae	<i>Schismus barbatus</i>	59
		* <i>Sporobolus caroli</i>	42
	Caryophyllaceae	* <i>Spergularia marina</i>	36
	Chenopodiaceae	<i>Atriplex pumilio</i>	4
		<i>Osteocarpum acropterum</i>	
		var. <i>deminuta</i>	3
		<i>Sclerolaena brachyptera</i>	4
		* <i>Chamaecybe drummondii</i>	1
	Euphorbiaceae		
	Poaceae	<i>Thinopyrum elongatum</i>	3
Manildra	Chenopodiaceae	<i>Halosarcia pergranulata</i>	15
	Fabaceae	* <i>Melilotus indica</i>	3
	Frankeniaceae	<i>Frankenia foliosa</i>	7
		<i>F. pulverulenta</i>	68

* = Native/naturalised at the site.

Differences between the Obley and Manildra sites

As indicated above, there were considerable differences in chemical properties between the soils at the experimental sites (Table 8). Physical expression of salinity also varied with puffiness and organic staining present at Obley but not at Manildra (Table 2). In the USA, Obley would be referred to as a 'black alkali' site, where sodium compounds react with soil organic matter to produce a dark-coloured residue which is drawn to the surface in dry periods (Daubenmire 1962).

Differences in the flora at each site were also evident, with some introduced and native/naturalised species being restricted to one site. These species, together with some infrequent (< 10%) native/naturalised species not shown in Table 4, are listed in Table 9.

Excluded from this table are some species that appeared to be restricted to one site in Table 4 but were known to occur outside the enclosure at the other site. Also excluded are species not adequately identified and those species that appeared to originate solely in litter samples from Broken Hill.

The near mutual exclusivity of the naturalised species *Spergularia marina* and *Melilotus indica* on central western saline sites was reported by Semple (1993). Of the semi-arid species, *Schismus barbatus*, *Frankenia pulverulenta*, *F. foliosa* and *Halosarcia pergranulata* were strongly site-specific. *Mesembryanthemum nodiflorum*, though occurring in 3% of plots at Manildra, occurred in 88% of the plots at Obley in the second year.

To be reasonably confident that there is a link between soil chemistry and species occurrence, three assumptions must be made: (1) that introduced species availability at both sites was the same (allowing for the lack of Broken Hill material at Manildra), (2) that seasonal rainfall and groundwater discharge were similar at both sites and (3) that the different mulching rates, 4t/ha at Obley and the higher rate of 8t/ha at Manildra, did not favour one species over another.

The high soluble salt contents at the sites (estimated ECe of 45 dSm⁻¹ at Obley and 28 dSm⁻¹ at Manildra) were probably sufficient to explain the establishment failure of some species. According to data cited by Taylor (1991), growth of *Trifolium fragiferum* (which failed to establish at either site) stops when EC_e exceeds 10 dSm⁻¹. As growth

of *Thinopyrum elongatum* ceases above an EC_e of 31.5 dSm^{-1} , its absence from the Obley site is understandable. However, if soluble salt concentration was the only explanation for species presence/absence, then all species which occurred at the high salinity site, Obley, should also have occurred at Manildra. Table 9 shows that this was not the case. Other soil properties which differed markedly between the Obley and Manildra sites — pH (10.9 v. 9.0), exchangeable Na percentage (61.4 v. 2.1) and exchangeable Ca/Mg percentage (36.4 v. 97.2) — were the most likely reasons.

Conclusions

A number of semi-arid species were able to establish and persist on the two central western saline sites. Though mulching and exclosure may be necessary for establishment, some species were particularly well adapted. *Schismus barbatus*, *Mesembryanthemum nodiflorum* and *Frankenia pulverulenta*, all annual species, spread beyond the exclosure boundary or at one or other site. Frequency data suggests they were as good, or better, colonisers than the pre-existing annuals.

Perennials such as *Halosarcia pergranulata* and *Frankenia foliosa* were less frequent. As many seeded for the first time in the second year — and some had not seeded at all — their ability to colonise bare scald is as yet unknown.

The reason for the absence of some of these species from the central west is open to conjecture. Lack of transport opportunity and the suspected newness of saline environments appear to be contributory factors. A vegetation survey of saline sites between, say, Manildra and Wentworth, might be instructive.

With the exception of some chenopods, the species introduced from semi-arid areas were of low forage value and some, such as the well adapted annuals, may become weeds. Obviously, any of these species that extend beyond the clinical boundary of a saline site would be an undesirable introduction.

Is there a place for species of low forage value or with other undesirable characteristics on saline sites? Saline scalds of the central west currently support a very sparse cover of low forage quality, mainly non-native species (see Table 2). From a purely reclamation point of view, any species that can extract water, reduce salt accumulation at the surface, and provide ground cover and sites for sediment accumulation, would be better than nothing, provided it did not spread to adjacent non-saline areas. However, as it would be unlikely that even high water-using species would on their own reclaim these sites, it would be difficult to convince landholders of the reclamation value of these species.

Species that were already native/naturalised at the experimental sites were also favoured by exclosure and mulching. The most frequent species were non-native annuals such as *Criteseion marimum* and *Parapholis incurva*, which are common on many saline sites in this region. Contrary to expectations, however, these species generally failed to establish on bare scalds in the absence of grazing. *Sporobolus caroli*, a native perennial with useful forage characteristics, and not normally associated with saline sites, was a good coloniser at Obley. It would be a useful addition to any saline site plant material screening program.

Seed of known salt-tolerant species failed to produce mature plants except in the case of *Puccinellia ciliata* (which increased in frequency), *Thinopyrum elongatum* (a few plants of which established at Manildra) and *Chloris truncata* (which increased in frequency but probably with input from local seed). Mulching appeared to have little detrimental effect in the establishment of *Puccinellia ciliata*, contrary to Fleck's (1967) findings. The failure of *Atriplex nummularia* and *Maireana brevifolia* may have been due to seedling

death by waterlogging and/or associated pathogens, as establishment of these species is best on mounds (Runciman & Malcolm 1989).

Many of the species performed well at only *one* of the experimental sites. This can be partly explained by the widely different soluble salt concentrations (as measured by electrical conductivity) at the two sites. Preliminary indications are that saline seepage scalds may also be able to be divided into types, e.g. on pH differences, or on whether Na or Ca/Mg dominate the cation exchange complex, and that plant responses on each type are likely to be different. This has implications for current species recommendations for saline site reclamation and for future evaluation trials of plant material for saline sites.

Acknowledgements

Messrs R. Bath, R. Richards and G. Scholz of the Soil Conservation Service provided much of the plant material from western NSW. Staff of the National Herbarium of NSW identified many of the species referred to in this paper. Messrs. P. Clowry of Manildra and S. Tourle of Wambangalang provided land on which the trials were carried out. Mr B. Wild provided valuable comments and Mrs R. Clementson very capably transformed our continually changing requirements into a final manuscript. Their assistance is gratefully acknowledged.

References

- Amor, R.L. and Piggin, C.M. (1977) Factors influencing the establishment and success of exotic plants in Australia. In *Exotic species in Australia — their establishment and success*. Proc. Ecol. Soc. Aust. 10, 15–26.
- Black, J.M. (1952) *Flora of South Australia* Part III (2nd Edn.) (Government Printer: Adelaide).
- Clarke, P.J. (1989) Coastal dune plants of New South Wales. *Technical Report 22*, Soil Conservation Service of NSW/Coastal Studies Unit Technical Report 89/4, University of Sydney.
- Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. & Leigh, J.H. (1981) *Plants of Western New South Wales* (Soil Conservation Service of NSW/Government Printing Office: Sydney).
- Daubenmire, R.F. (1962) *Plants and environment* (Second Edn.) (John Wiley & Sons: New York).
- Eckert, D.J. (1987) Soil test interpretations. Basic cation saturation ratios and sufficiency levels. In *Soil testing: sampling, correlation, calibration and interpretations*. Soil Science Society of America Special Publication 21.
- Fleck, B.C. (1967) A note on the performance of *Agropyron elongatum* (Host.) Beauv. and *Puccinellia* (Parl.) sp. in revegetation of saline areas. *J. Soil Conserv. Serv. NSW*. 23: 261–269.
- Hamilton, G.J. (1972) Investigations into the reclamation of dryland saline soils. *J. Soil Conserv. Serv. NSW*. 28: 191–211.
- Jacobs, S.W.L. (1990) Chenopodiaceae. In *Flora of New South Wales* Volume 1 (Ed. G.J. Harden) (NSW University Press: Kensington).
- Jacobs, S.W.L. & Highet, J. (1990) Aizoaceae. In *Flora of New South Wales* Volume 1 (Ed. G.J. Harden) (NSW University Press: Kensington).
- Jacobs, S.W.L. & Pickard, J. (1981) *Plants of New South Wales. A census of the cycads, conifers and angiosperms* (Government Printer: Sydney).
- Kodala, P.G. & Foster, D.A. (1990) Common plants and soil salinity in the Lower Boro area, Southern Tablelands, New South Wales. *Cunninghamia* 2: 217–222.
- Lawrie, J.W. (1991) Soils and erosion. In *Lands of the north-west corner of NSW*. Technical Report 12, Soil Conservation Service of NSW.
- Logan, J.M. (1958) Erosion problems on salt affected soils. *J. Soil Conserv. Serv. NSW*. 14, 229–242.
- Matters, J. & Bozon, J. (1989) *Spotting soil salting. A Victorian field guide to salt indicator plants* (Conservation, Forests & Lands: Melbourne).
- Miller, C. (1990) Frankeniaceae. In *Flora of New South Wales* Volume 1 (Ed. G.J. Harden) (NSW University Press: Kensington).

- Pope, K. & Abbott, T.S. (1989) Understanding salinity and sodicity measurement. *Information on Salinity* (NSW Agriculture).
- Runciman, H.V. & Malcolm, C.V. (1989) Forage shrubs and grasses for revegetating saltland. *Bulletin No. 4153*, W.A. Department of Agriculture.
- Semple, W.S. (1993) Native and naturalised plants of some saline sites in the Central West of NSW. *Technical Report 31*, Soil Conservation Service of NSW.
- Slavich, P.G. & Petterson, G.H. (1993) Estimating the electrical conductivity of saturated paste extracts from 1: 5 soil: water suspensions and texture. *Aust. J. Soil Res.* 31: 73–81.
- Taylor, S. (1991) *Dryland salinity introductory extension notes* (Department of Conservation and Land Management: Sydney).
- Wace, N. (1977) Assessment of dispersal of plant species — the car-borne flora of Canberra. In *Exotic species in Australia — their establishment and success*. *Proc. Ecol. Soc. Aust.* 10: 167–186.
- Wagner, R. (1957) Salt damage on soils of the Southern Tablelands. *J. Soil Conserv. Serv. NSW.* 13: 33–39.
- Wheeler, D.J.B., Jacobs, S.W.L. & Norton, B.E. (1990) *Grasses of New South Wales* (2nd edn.) (University of New England: Armidale).
- Williams, B.G. & Bullock, P.R. (1989) The classification of salt-affected land in Australia. *Technical Memorandum 89/8*, CSIRO Division of Water Resources.

Manuscript received 7 October 1993

Manuscript accepted 14 March 1994

The native grasslands of the Monaro region: Southern Tablelands of NSW

Print 66524

J.S. Benson

Benson, J.S., (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1994. The native grasslands of the Monaro region: Southern Tablelands of NSW. *Cunninghamia* 3(3): 609–650. Eight grassland plant communities were defined from a cluster analysis of vascular plant species recorded in 62 quadrats surveyed between the Australian Capital Territory (35° 11' S) and the Victorian border (36° 53' S) (148° 35'–149° 25' E). 265 taxa were recorded, 189 native and 76 (29%) exotic. Five of the native species are registered as rare or threatened in Australia. Cluster analyses using cover data were deemed superior to presence/absence data. Hybrid, non-metric multi-dimensional scaling revealed that altitude is the main determinant for the distribution of native grassland species and communities.

The native grasslands on the tableland tract of the study area (none of which are protected in conservation reserves) contain a high number (> 35%) of exotic species due to more than a century of grazing and decades of pasture improvement in the surrounding countryside. A number of sites are recommended for protection based on their species diversity, presence of threatened species, or because they are representative of a particular plant community. Many of these are dominated by *Themeda australis*, indicating a lack of continuous grazing. Most of these are located in fenced-off areas such as cemeteries, roadsides or travelling stock reserves (TSRs). Until more research is done on native grassland management it is recommended that practices such as intermittent grazing or occasional burning in autumn should continue. Significant remnants on public land should be managed for grassland conservation.

Introduction

It is remarkable that such an extensive tract of country as that known as the Monaro Plains, should naturally be almost destitute of trees and shrubs ... the country is made up of clear undulating plains, with only a few isolated tree-clad localities. (Cambage 1909)

Recent studies of native grasslands and native grass species in south-eastern Australia have investigated their benefit to grazing or uses in revegetation (Leigh 1991, Roberts 1991, Lodge et al. 1991, Jefferson et al. 1991). Other studies have highlighted the rarity of native grasslands and proposed areas for their conservation (Stuwe 1986, Frawley 1991, McDougall & Kirkpatrick 1993).

In 1991 the World Wide Fund for Nature (WWF) funded surveys of temperate grasslands remnants in four states of south-eastern Australia: New South Wales (including the Australian Capital Territory ACT), Victoria, South Australia and Tasmania. The results of this study are presented in McDougall and Kirkpatrick (1993). As part of that report, Benson and Wyse Jackson (1993) derived a floristic classification of the Monaro native grasslands using TWINSpan (Hill 1979). Through a combination of iterative (Kirkpatrick 1983) and score-based evaluation methods (Wright 1977), Benson and Wyse Jackson (1993) identified 17 grassland sites of significance for nature conservation.

This paper reclassifies the Monaro data using the flexible UPGMA cluster strategy (PATN package, Belbin 1993) and incorporates additional quadrat data mainly from



Figure 1. Estimated original extent of native grasslands at the time of European settlement (grey-toned area), excluding subalpine and alpine grasslands above 1500 m. Only a small proportion remains today. Dotted areas are observation reserves. From Costin (1954) and author's knowledge.

the Montane tract (Costin 1954) on the eastern fringe of Kosciusko National Park. Analysis of the importance of some environmental attributes in determining community distribution was also undertaken. Discussion is provided on the floristic composition, environmental determinants, condition and conservation status of native grasslands and rare grassland species on the Monaro. UPGMA and TWINSpan are compared regarding their effectiveness in classifying the grassland communities.

For the purposes of this study, the term 'native grassland' refers to areas that contain predominantly native grass and forb plants and are largely devoid of trees and shrubs. In some circumstances a residual understorey of native grass and forb species may exist after the clearing of trees and this may resemble an original native grassland. This survey concentrated on areas that were considered to have been treeless and dominated by herbaceous plants at the time of European settlement.

The study area

The study area is located on the Southern Tablelands of NSW between 35° 11' S and 36° 53' S and 148° 35' and 149° 25' E. It includes most of the tableland (600–950 m a.s.l.) and montane (950–1500 m a.s.l.) climatic provinces of the Monaro region defined by Costin (1954). This region extends from Canberra and Queanbeyan in the north to the Victoria border in the south, bounded in the east by the Kybean Range and in the west by the Snowy Mountains (Figure 1).

Based on the area of grassland mapped in Costin (1954), notes in the early annals of European explorers and the author's field inspections, the pre-European extent of grassland on the Monaro is estimated to have been approximately 250 000 ha.

The elevation of the sites sampled range from 579 m at Queanbeyan to 1380 m at Boggy Plain in Kosciusko National Park. The survey excluded approximately 50 000 ha of grasslands in the alpine and subalpine communities above 1500 m in Kosciusko National Park (McRae 1989) in NSW and subalpine and montane grasslands located in Namadgi National Park in the Australian Capital Territory.

Most of the undulating tableland tract of the region, where the largest area of native grassland once existed, is privately owned and grazed by stock; minor cropping takes place on alluvial flats. Most of the higher altitude or more rugged terrain in the region is located in national parks and state forests.

Climate

On the Monaro, rain falls predominantly in winter. In the south, Dalgety receives only 459 mm annual precipitation. This increases eastwards to Nimmitabel (688 mm) and north-westwards to Adaminaby (701 mm) (Table 1). At the northern end of the study area, Queanbeyan receives an average of 573 mm. Rainfall increases markedly in the mountain ranges to the east and the west. The relative aridity of the tableland section of the Monaro is due to a rainshadow effect which has existed since at least the Miocene (Ride et al. 1989).

Temperatures are cold in winter and mild in summer. The mean temperature of the coldest month ranges from 1.1° C at Adaminaby to 6.1° C at Queanbeyan (Table 1). In summer the mean temperature of the warmest month ranges from 21.1° C at Queanbeyan to 15.6° C at Adaminaby. The coldest temperatures in the study area are experienced in the montane frost hollow valleys in Kosciusko National Park.

Table 1. Climatic attributes of locations on the Monaro (from Costin 1954, Flood 1980)

Location	Latitude	Longitude	Alt (m)	M.C. (°C)	M.H. (°C)	M+9	R (mm)
Queanbeyan	35° 21' S	149° 28' E	579	6.1	21.1	9	573
Cooma	36° 14' S	149° 07' E	811	4.4	18.9	8	476
Nimmitabel	36° 30' S	149° 17' E	1068	2.8	15.8	7	688
Bombala	36° 55' S	149° 14' E	705	5.0	17.8	8	625
Jindabyne	36° 24' S	147° 40' E	945	1.7	16.1	6	547
Dalgety	36° 36' S	148° 50' E	896	3.9	18.3	7	459
Adaminaby	36° 03' S	148° 42' E	1067	1.1	15.6	7	701
Kiandra	35° 52' S	148° 32' E	1395	-0.6	13.3	5	1602

M.C. = mean temperature of coldest month (Celsius)

M.H. = mean temperature of hottest month (Celsius)

M+9 = months with mean temperature > 9° Celsius

R (mm) = mean annual rainfall in mm

Geology

The underlying rocks are mainly Palaeozoic sediments which have been folded, faulted and metamorphosed during the formation of the Lachlan Fold Belt which covers a large section of south-eastern Australia (Ollier & Wyborn 1989). Granite intrusions, including the Kosciusko Batholith intruded in the Silurian period. The land surface eroded to a palaeoplain by the Jurassic. This was uplifted, due to undetermined causes, in the Miocene by way of large fault blocks (Ollier & Wyborn 1989). Between 45 and 34 m yrs B.P., during the Eocene, a shield-like volcano erupted causing basalt flows over the southern half of the Monaro. This volcano is thought to have been centered on Brown Mountain (Ollier & Taylor 1988) which is located on the south-eastern fringe of the present Monaro tableland.

The rocks outcropping today vary greatly from the north to the south. Between Canberra and Cooma the main substrates are Silurian and Ordovician volcanics, mudstones, shales and limestones. Some of the larger valleys in the Canberra area, where native grassland was known to exist, are composed of Cainozoic sediments. The elevated region between Cooma and Bombala in the south is mainly composed of Eocene basalt. The western part of the study area in Kosciusko National Park and between Adaminaby and Dalgety is composed of granite and sediments. In the east, the Kybean Range is composed of granite.

The large number of geological types mapped by the Australian Geological Survey in the region have been amalgamated into 12 major groups by Spate (1993) based on their similarity of mineral composition. Soils in the study area are documented in Costin (1954). They include peat and humus podsols in the montane tract; chocolate soils or chernozems on the high basalt plateau between Cooma and Bombala; and red, grey and brown clayey soils (podsoils and laterites) derived from volcanic and sedimentary substrates occurring elsewhere on the tableland.

While the drainage in the region tends to follow the north-south orientated bedrock, some rivers have been captured and diverted to the coast with the westwards retreat of the great escarpment (Ollier 1982). Today most drainage is dendritic, except in the south where remnant landforms associated with the Monaro Volcano cause the drainage to be radial.

Some of the higher ground within the study area may have been affected by periglacial activity at the height of the last ice age (18–23 000 yrs B.P.) (A. Costin pers. comm.). The numerous lakes set among the grasslands on the basalt and granite

plateau on the southern Monaro are an interesting geomorphological feature (see Benson and Jacobs 1994).

Land-use history and previous botanical studies

A detailed history of Aboriginal occupation in the Monaro is provided by Flood (1980). Due to cold temperatures, and possibly lack of game, it is likely that Aborigines did not favour year-round occupation of the higher parts of the Monaro compared to lower elevations. In autumn, the Aborigines may have gathered and baked seeds of grasses such as *Themeda australis*. However, it seems that seed grinding was not a major part of the economy of the tribes occupying the Monaro. The first European botanist to visit the region, Allan Cunningham, observed Aborigines burning grasslands in Autumn (Havard 1936).

The first European to explore the northern part of the Monaro was Throsby in 1821. Settlement had advanced as far south as Berridale by 1827 (Costin 1954). Both Cunningham and Lhotsky mention the existence of extensive open grasslands in the Goulburn, Lake George and Limestone Plains (Canberra) areas. Lhotsky (1835) estimated that there were 10 000 hectares of grassland on the Limestone Plains. South of the Limestone Plains he describes *Poa* tussock grasslands and gives one of the first descriptions of the Monaro grasslands in the vicinity of Cooma:

The scene all around was composed of undulating downs, long projected hills among them, covered with a very few trees.

The reasons for this absence of trees on the Monaro have long held the interest of botanists. Cambage (1909) suggested the lack of trees could be explained through a combination of low rainfall, cold temperatures, drying summer winds and the structure of the soil. From 1830 onwards the squatters moved in and carved up the country into grazing runs and only a small fraction of the region remained in government ownership. As early as 1840, only 15 years after the first Europeans settled on the Monaro, the explorer Strezlecki expressed concern about the effects that drought, cropping and overgrazing were having on soil erosion (Hancock 1972). Small-scale pasture improvement began in the 1860s. Rabbits proliferated after 1900. Clovers were first sown in the 1920s but pasture improvement accelerated after the second world war, along with the application of superphosphate fertiliser (Hancock 1972).

Cambage (1909 and 1918) provided lists of plant species occurring in the area. A detailed botanical study of the region was undertaken by Costin (1954). This work intuitively classified vegetation to an alliance level and a small scale vegetation map was produced. Costin (1954) recognised two main grassland subformations in the study area; dry tussock grassland dominated by *Stipa scabra* and *Stipa bigeniculata* and wet tussock grassland typified by the presence of *Themeda australis*, *Poa*, *Juncus* and *Carex* species. Pryor (1954) described and mapped the major plant communities occurring in the ACT. A quadrat-based phytosociological study of pastures was carried out by Doing (1972).

Several detailed grassland studies have concentrated on the ACT section of the study area where about 40 grassland remnants have been surveyed (Chan 1980, Hogg 1990, Frawley 1991). The waterplants growing in the lakes on the southern Monaro have been sampled by Benson and Jacobs (1994).

Methods

Compared to their usefulness in vegetation surveys of forest and shrubland, aerial photographs or LANDSAT images proved to be of limited assistance in distinguishing native from modified grasslands on the Monaro. It was therefore decided to select grassland sites through expert advice and by undertaking ground traverses of the countryside. Many sites were selected on the recommendations of the NSW Department of Agriculture, Rural Lands Protection Board, CSIRO and University of Canberra. Additional sites were selected during road traverses on the basis of their apparent natural condition compared to surrounding paddocks. Most of these were located within smaller fenced-off paddocks postulated to have been subject to less continuous grazing. Sampling also aimed to cover the region's main rock and soil types, a range of altitudes and various landform positions (flat, slope, ridge). This meant that some poorer quality sites were recorded to fulfill this aim (for example, drainage lines or flats dominated by *Poa labillardieri* and exotic species).

Sixty-two grassland sites were sampled by way of 100² m quadrats placed within them. Sixty quadrats were sampled between October 1991 and January 1992 — a period that coincided with favourable rainfall and abundant flowering. A further two sites were sampled in February 1993. All plant species within a quadrat were recorded and assigned a cover rating based on a six point cover scale (< 1%, 1–5%, 6–25%, 26–50%, 51–75%, 76–100%). Physiographic attributes (slope, aspect, altitude, soil texture, geology and drainage), vegetation structure, land tenure and an estimation of degree of disturbance (including percentage of exotic species) were recorded at each site (Table 2). On the advice of Spate (pers. comm.), his 10 geological categories (Spate 1993) present in the study area were reduced to five by amalgamating three volcanic and sediment categories which have similar compositions (the limestone and Cainozoic sediment categories were maintained).

Soil categorisation at each site was based on observations of texture and colour and reference to Costin (1954). The Australian Map Grid (AMG) coordinate was derived by a geographical positioning system device and topographic maps. Plant species nomenclature follows the *Flora of New South Wales* (Harden 1990–1993).

Data analysis

Quadrats and species were classified into groups by way of an agglomerative hierarchical classification using the Kulczynski coefficient dissimilarity measure and applying the flexible unweighted paired group arithmetic averaging (UPGMA) sorting strategy (PATN, Belbin 1993). The benefits of using the Kulczynski coefficient compared to other measures are discussed in Faith, Minchin and Belbin (1987).

Several UPGMA analyses were performed. One analysis incorporated all species including cover ratings in a matrix of 62 sites (objects) and 265 taxa (attributes). Another analysis excluded exotic species but still included cover ratings, resulting in a reduced matrix of 62 x 189 (it was considered that this analysis may assist with the interpretation of any underlying native floristic patterns not clouded by exotic taxa, many of which have been imposed on the landscape through direct pasture seeding, for example *Trifolium* spp). Further analyses, using all species and native species only, excluded cover ratings and included presence/absence data only. The aim was to assess the importance or otherwise of cover rating in the sorting of sites into groups.

A check on sites suspected to be misplaced in the groupings derived by the favoured UPGMA analysis (this excluded exotic species and included cover ratings of native

species) was undertaken by examining the five nearest neighbours of those sites that were generated from the ASO file in PATN using the Kulczynski dissimilarity measure.

Two-way tables for the 'all species' and 'native species only' matrices were generated using the 2-Step association measure on species and Kulczynski coefficient on sites (Belbin 1993). These helped to identify common and indicator plants for each UPGMA defined community and enabled a plant list to be compiled showing the frequency of taxa occurring in each plant community.

Hybrid nonmetric multidimensional scaling (NMDS) (Kruskal 1964) was undertaken to ordinate the quadrat data along three vectors (using PATN, Belbin 1993). NMDS is a robust technique to examine compositional dimensions associated with environmental gradients (Minchin 1987).

To help understand the nature of the environmental space being described by these vectors, a number of analyses were carried out. Scatter plots of sites in the ordination space transcribed by the three vectors were made to look for simple relationships. The GSTA (Group Statistics) module of PATN (Belbin 1993) was performed on the environmental attributes geographic position (easting and northing) and altitude, grouped according to the community analysis. The results of these analyses suggested that vector 2 may describe an altitudinal surrogate. Scatter plots were then constructed for sites which were numbered as per their UPGMA classified community (1–8).

Results

Floristic composition

Two hundred and sixty-five vascular plant species (Appendix 1) were recorded from the 62 quadrats. Of these, 189 are native species and 76 (29%) exotic. The most frequent native species recorded were *Poa sieberiana* (58%), *Acaena ovina* (52%), *Themeda australis* (50%), *Leptorhynchus squamatus* (42%), *Asperula conferta* (39%), *Carex inversa* (37%) and *Elymus scaber* (37%). The most frequent exotic species were *Hypochaeris radicata* (69%), *Vulpia myuros* (58%), *Trifolium campestre* (47%), *Trifolium arvense* (44%), *Bromus hordeaceus* (42%) and *Acetosella vulgaris* (39%).

Large numbers of exotic species were found in most communities but the ratio of native to exotic species varied (Table 2). Sites dominated by *Poa labillardieri* (Community 8) on average contained 52% exotic species. In contrast, only 6% of species recorded in the montane sod-tussock grassland (Community 6) were exotic. Community 3, dominated by *Themeda australis*, contained a lower percentage of exotic species (33%) than the other communities located below 1200 m altitude.

Sites with the highest number of native species were located in lightly grazed areas such as Kosciusko National Park, site 336 at Mount Jerrabomberra, Site 411 on the Snowy Plain, site 354 in the Yaouk Valley and the two sites near Adaminaby (352, 357).

Plant community analysis

Eight communities were defined by the favoured UPGMA cluster analysis selected at the 0.8 level of dissimilarity (Figure 2). This analysis excluded exotic species and included cover data for the native species in the matrix. If taken at the 0.74 dissimilarity level the 17 sites in Community 3 would separate into two groups. It was decided that their overall similarities outweigh their differences, although two sub-

Table 2. Attributes of sample sites

Site	East	North	Location	Geol	Soil	Landf.	Alt	SI	Asp	Tsp	Nsp	Esp (%)	Tenure
336	6996	60832	Mt Jerrabomberra	S/V	Red clay	LS	610	4	280	39	32	7 (18)	Private
348	6902	60997	Navigation Centre	S/V	Red clay	LS	580	8	0	31	16	15 (49)	Navy
350	6981	60822	Poplars	S/V	Red clay	LS	590	2	320	21	12	9 (43)	Private
349	6973	60930	Campbell	S/V	Red clay	LS	600	3	110	29	18	11 (38)	Open space
351	6882	60996	Lake Ginninderra	S/V	Red clay	LS	580	8	280	25	14	11 (44)	Open space
337	6930	60145	Gungarlin	S/V	Loam clay	MS	600	5	120	20	10	10 (50)	ACT Govt.
338	6832	60737	Paddys River	G	Loam clay	MS	690	11	40	22	12	10 (45)	Private
364	6928	60007	2CY Tower	S/V	Loam clay	F	600	0	—	23	13	10 (43)	Private
366	6827	60741	Paddys Road	G	Loam clay	US	710	3	30	30	19	11 (37)	Roadside
368	6893	60927	Aust. Museum	S/V	Loam clay	LS	570	5	160	23	10	13 (56)	Open space
367	6994	60932	Airport Beacon	CS	Loam clay	F	590	1	240	24	17	7 (29)	Airport
345	6819	59867	Slacks Plain	S/V	Red clay	LS	900	2	330	29	16	13 (45)	Roadside
363	7099	59955	Numeralla Cemetery	S/V	Red clay	LS	610	4	280	16	9	7 (44)	Cemetery
355	6962	60063	Bredbo	S/V	Red clay	LS	720	3	90	39	30	9 (23)	Private
358	6958	60094	Bredbo	S/V	Red clay	R	810	3	30	30	20	10 (33)	Private
356	6557	59551	Beloka Cemetery	S/V	Red clay	US	860	4	315	33	20	13 (39)	Cemetery
352	6617	60150	Adaminaby Hill	S/V	Red clay	US	1040	5	120	35	23	12 (34)	Private
354	6640	60356	Yaouk	CS	Red clay	F	1110	0	—	41	32	9 (22)	Private
357	6612	60144	Adaminaby Saleyards	S/V	Red clay	R	1020	3	80	34	22	12 (35)	TSR
361	6533	59872	Round Plain Church	CS	Grey clay	F	1080	2	160	32	18	14 (44)	Church
408	7100	59575	Kydra	G	Grey clay	R	1100	5	160	24	16	8 (33)	TSR
353	6946	60717	Royalla	S/V	Red clay	LS	890	1	280	32	21	11 (34)	Railway
360	6947	60574	Williamsdale	S/V	Grey clay	LS	750	1	90	31	20	11 (35)	Railway
365	6956	60555	Waterholes	S/V	Red clay	MS	770	1	90	21	16	5 (24)	Railway
359	6537	59869	Round Plain	CS	Grey clay	F	1100	1	180	24	15	9 (37)	TSR
420	7064	59207	Black Lake	B	Choc/cher	R	960	3	270	23	17	6 (26)	TSR
362	6828	60812	Kambah	S/V	Grey clay	US	550	10	330	33	24	9 (27)	Cons. Res.
419	6793	59385	Bungarby	B	Choc/cher	R	960	3	270	21	15	6 (29)	Private
339	6846	59476	Avonlake	B	Choc/cher	US	880	4	120	28	19	9 (32)	TSR
340	6920	59746	Bondo	B	Choc/cher	LS	930	4	90	22	14	8 (36)	TSR
342	6861	59768	North Brother	B	Choc/cher	LS	940	3	240	31	16	15 (48)	TSR
343	6986	59750	Rock Flat	B	Choc/cher	LS	890	5	210	29	14	15 (52)	TSR
341	6828	59677	Ravensworth	B	Choc/cher	MS	1010	4	300	23	16	7 (30)	TSR
344	7013	59300	Home Dale	B	Choc/cher	US	900	5	50	23	14	9 (39)	TSR
346	6964	59779	Manaroo	B	Choc/cher	MS	920	8	290	22	14	8 (36)	Private
347	6899	59710	South Brother	B	Choc/cher	MS	1100	7	90	9	3	6 (66)	Private
369	6604	59670	Birkenhead	G	Sandy clay	R	940	3	320	23	16	7 (30)	Private
372	6791	59169	Quidong	L	Loamy clay	F	630	3	250	24	15	9 (37)	Private
370	6801	59156	Quidong	L	Loamy clay	US	700	9	220	31	21	10 (32)	Private
374	6636	59583	Dalgety	G	Sandy clay	US	760	6	210	18	11	7 (39)	TSR
376	6669	59621	Wyreela	G	Sandy clay	US	800	4	100	20	12	8 (40)	Private
377	6965	60853	Symonston	S/V	Grey clay	F	580	0	—	22	8	14 (63)	Private
371	6964	59252	Bukalong	S/V	Sandy Clay	R	820	2	50	23	14	9 (39)	Roadside
375	6714	59582	Black Range	S	Sandy clay	R	820	0	—	22	12	10 (45)	Roadside
378	6821	59503	Timbury Range	G	Sandy clay	R	940	4	290	13	5	8 (62)	Private
373	6823	59533	Maffra Church	G	Sandy clay	R	930	0	—	18	11	7 (39)	Church

409	6496	60584	Coolamine	L	Humus podsol	F	1260	4	90	26	26	0 (0)	NP
410	6452	60601	Long Plain	S/V	Humus podsol	F	1360	1	150	32	30	2 (6)	NP
418	6489	60290	Nungar Plain	S/V	Humus podsol	F	1340	3	180	26	24	2 (8)	NP
413	6399	60485	Long Plain	S/V	Humus podsol	F	1320	1	30	29	27	2 (7)	NP
411	6403	59933	Snowy Plain	G	Humus podsol	F	1340	2	150	34	32	2 (6)	Private
417	6391	59947	Davies Hut	G	Humus podsol	F	1320	0	—	22	21	1 (5)	NP
416	6398	59862	Botheram Plain	G	Humus podsol	F	1300	0	—	30	26	4 (13)	NP
412	6435	60294	Boggy Plain	G	Humus podsol	F	1380	2	340	32	28	4 (12)	NP
415	6392	59947	Snowy Plain	G	Humus podsol	F	1370	1	0	31	27	4 (13)	Private
414	6521	60364	Gulf Plain	S/V	Humus podsol	F	1240	3	70	28	25	3 (11)	NP
402	6987	59699	Rock Flat Creek	B	Black cher	C	930	2	330	13	6	7 (54)	Private
405	6670	59621	Wyreela	G	Humus loam	C	800	6	120	20	9	11 (55)	Private
403	6998	59975	Spring Bush	S/V	Loamy clay	C	740	2	80	7	4	3 (43)	Private
407	6681	60057	Caddigat Creek	S/V	Humus loam	C	1160	0	—	16	8	8 (50)	Private
404	7172	59727	Kybean River	G	Humus loam	C	1020	0	—	13	5	8 (62)	Private
406	6840	60168	Joes Swamp	G	Humus loam	C	1300	2	90	21	11	10 (48)	Private

Notes.

Full Australian Map Grid (AMG) references are given. **Alt** = altitude; **Sl** = slope in degrees from horizontal; **Asp** = aspect; **Tsp** = total no. species; **Nsp** = no. native species; **Esp** (%) = no. exotic species (percentage of total). **Geol** = Geology (from Spate (1993): S/V = Palaeozoic sediments or volcanics; CS = Cainozoic sediments; G = granites; L = limestone; B = basalt). **Soils** are classified from field observations and from Costin 1954. Choc/cher = chocolate or chernozem soils derived from basalt. **Landf. (LF)** = LS: lower slope; MS: mid-slope; US: upper slope; R: ridge; F: flat; C: creek or drainage line.

Site 367 has been transferred from Community 3b (where it was placed in the UPGMA analysis) to Community 2 (see text).

groups (3a and 3b) are recognised based on a number of species exclusive to one or the other (for example *Dodonaea procumbens* only occurs in 3a).

One site, 367, which is dominated by *Themeda australis* and *Poa sieberiana*, was manually transferred from Community 3 to Community 2 in the classification based on an examination of the location of its five nearest neighbours in the analysis, its species composition and its geographical position in the ACT. Two sites in Community 2 (sites 368 and 337) listed site 367 as one of their closely allied sites, yet the two nearest neighbours to site 367, grouped into Community 3, did not have 367 as their nearest neighbour. Site 367 also contains *Eryngium rostratum* with *Juncus filicaulis* recorded as being adjacent to the quadrat. Both of these species are more typical of sites grouped under Community 2 than Community 3.

Relationships of site groupings to site attributes can be seen by examining Table 2, Figure 3 (altitude versus vector 2) and Figure 4 (geographic position map). Table 2 reveals the fidelity that some communities have for geology and soil type and therefore the value of these attributes as predictors of the vegetation. Community 4, for example, is restricted to basalt substrate weathering to deep chocolate or chernozem soils. Alternatively, Community 3 is less predictable by way of these attributes as it is present on a range of substrates and soil types.

Altitude was revealed as a possible explanatory variable by examination of Table 2 along with the GSTA analysis. A significant correlation ($p < 0.001$) was found between altitude and vector 2 using all communities (Figure 3; $r = -0.73$). thus, vector 2 may describe a surrogate for an altitudinal gradient, or at least one in which altitude plays a part (for example moisture).

Some communities also display high geographical fidelity. Figure 4 shows how in both eastings and northings Community 1 is tightly clustered and is geographically discrete (ACT region). Community 2 occupies an equally narrow longitudinal band but extends latitudinally much further. Community 4 also occupies a discrete space (south of Cooma). Community 3 is the most widespread of the communities occupying sites from near Queanbeyan to Bombala. There is significant overlap between communities 6 and 7, however they have been separated by the UPGMA classification, and probably reflect local environmental variation.

UPGMA: all species versus native species only

Including the exotic species in the analysis resulted in three of the 62 sites (sites 347, 357 and 367) changing communities. These site changes were judged to have weakened the classification based on site floristics and geographical position. For example it resulted in a poorer relationship of the two subsections of Community 3 (3a and 3b).

UPGMA: cover rating versus presence/absence

When cover rating for each species were replaced with presence/absence in the UPGMA analysis of native species only, changes occurred in the groupings of sites. Group definition became less defined and the dendrogram generated more groups at the 0.8 level of dissimilarity. Communities 6 and 7 did not change, but eight sites (338, 339, 371, 345, 367, 375, 377 and 402) moved between the other groups. Some of these changes contradicted the classification which used cover data. For example, site 402, which is a species-poor site dominated by *Poa labillardieri*, was placed distant from Community 8 where it clearly belongs and into a group resembling Community 2. Likewise, site 375, which is dominated by *Stipa* grasses, changed from its previous logical grouping with other *Stipa* grass sites and was placed among the *Poa sieberiana* dominated sites that occur on basalt.

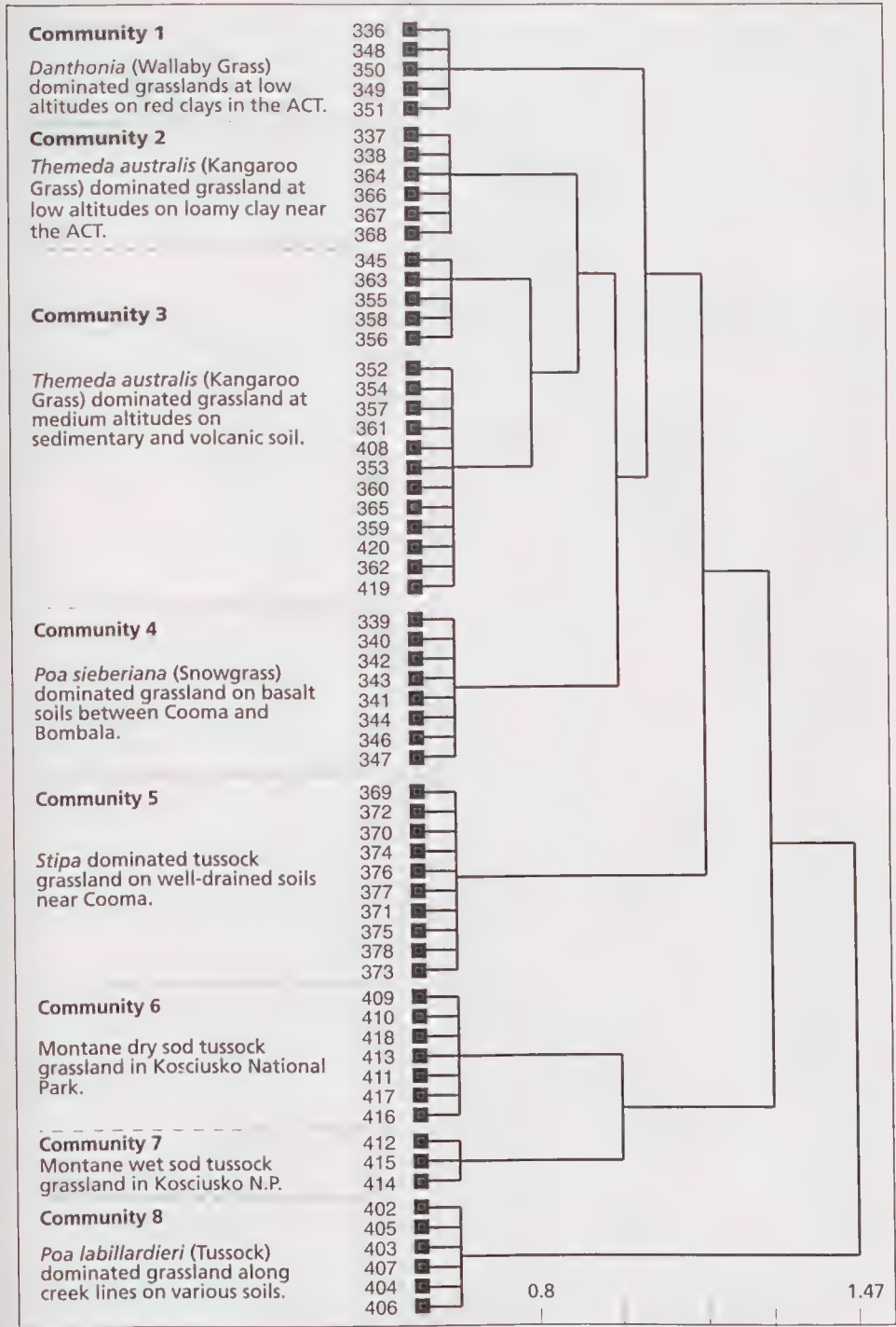


Figure 2. Agglomerative classification of sites by their similarity of vascular plant composition selected at the 0.8 disassociation value. This analysis is based on cover ratings for native species in each quadrat and excludes exotic species.

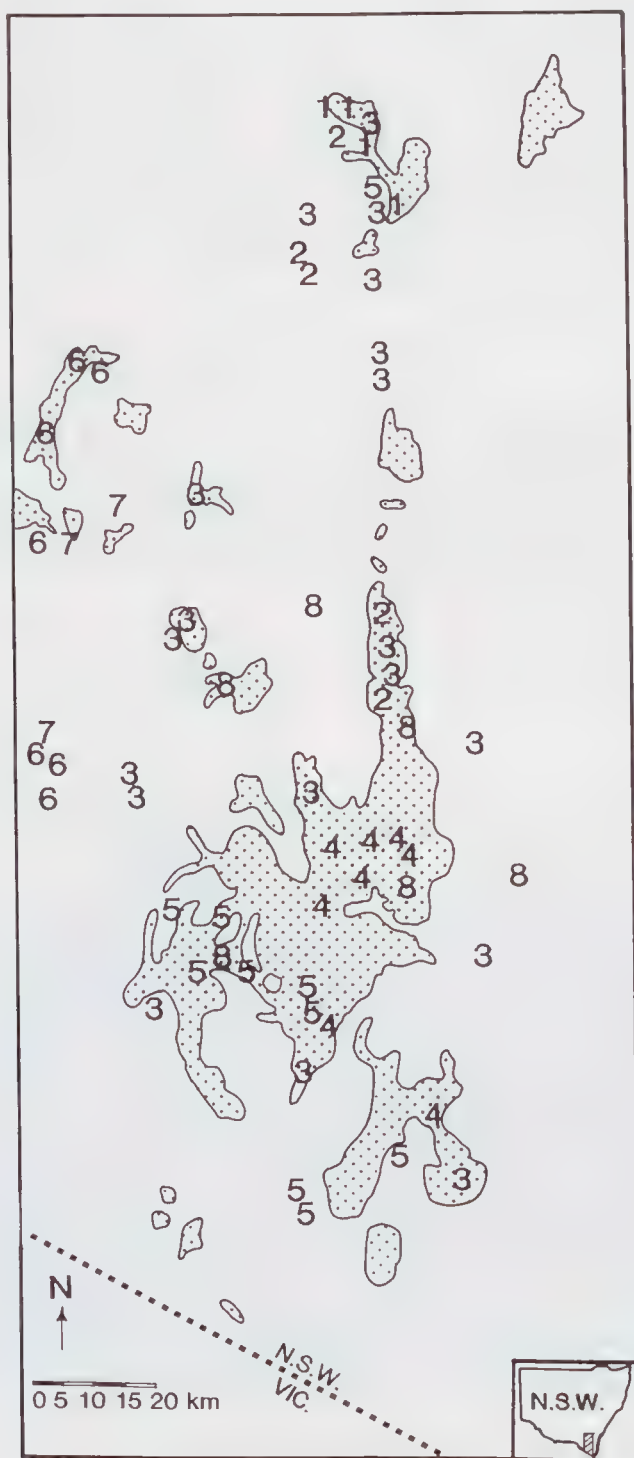


Figure 4. Scatter plot showing the Australian Map Grid locations of the sample sites in the study area. Sites are classified into communities 1–8.

or to that generated by the polythetic hierarchical divisive classification TWINSpan (Hill 1979) presented in Benson and Wyse Jackson (1993). The UPGMA sorting strategy yielded groups with improved correlation with substrate and geographical location than the TWINSpan sorting strategy. For example, the two sites within 1 km of each other on the same soils and altitude at Adaminaby (sites 357 and 352) were split into different groups by TWINSpan but lumped into the same group by all of the UPGMA analyses (native species only, all species, cover ratings, presence/absence). TWINSpan separated these two sites at an early level in its sorting, principally because site 352 was dominated by *Themeda australis* and site 357 lacked this species because it had been recently grazed.

Grassland communities

The structure and floristics of the eight plant communities selected from the favoured UPGMA analysis are detailed below. The structural classification is based on Walker and Hopkins (1990). Dominant native and common weed species have been selected by examining a two way table generated using cover ratings and all species. Indicator species were also selected from this two way table on the basis of their frequency of occurrence in a community or because they were largely confined to a single community.

• Community 1. *Danthonia* spp.–*Asperula conferta*–*Bothriochloa macra* low grassland on the northern Monaro

No. sample sites: 5

Structure: Mid-dense, low tussock grassland.

Mean no. native spp. per site: 18

Mean no. exotic spp. per site: 11 (38%)

Dominant native species: *Danthonia carphoides*, *Danthonia auriculata*, *Asperula conferta*, *Bothriochloa macra*, *Vittadinia muelleri*, *Chrysocephalum apiculatum*, *Goodenia pinnatifida*.

Indicator native species: *Danthonia carphoides*, *Danthonia auriculata*, *Aristida ramosa*, *Triptilodiscus pygmaeus*, *Goodenia pinnatifida*, *Pterostylis mutica*.

Common exotic species: *Vulpia myuros*, *Bromus hordeaceus*, *Plantago lanceolata*, *Parentucellia latifolia*, *Moenchia erecta*, *Hypochaeris radicata*, *Trifolium campestre*, *Aira elegantissima*.

Landform, geology and soils: Occupies the lower slopes on the margins of valleys composed of paleozoic sediments and volcanics which weather to form red clay soil.

Distribution: Confined to the ACT and Queanbeyan districts on the northern Monaro. This area contains the lowest elevations and warmest temperatures in the study area; altitude range 580–610 m.

Condition: With the exception of site 336 at Mount Jerrabomberra, this community has a high number of weeds but areas subject to mowing at a height of 10 cm or higher appear to contain healthy stands of *Danthonia* and other native species.

Threats and conservation status: The main threat is urban expansion and the small size of the remnants. No sites are currently protected in reserves.

Key sites for conservation: Site 336, Mount Jerrabomberra, contains one of the largest remaining populations of the endangered plant, *Rutidosia leptorhynchoides*. Site 348, Navy Navigation Centre Belconnen, contains the largest *Danthonia carphoides* dominated remnant sampled in the survey. The site is important as a habitat for a large population of an endangered moth, *Synemon plana*, which feeds on the roots of *Danthonia carphoides* (Edwards 1989).

• Community 2. *Themeda australis*–*Juncus filiformis* grassland of the ACT

No. sample sites: 6 (including site 367)

Structure: Mid-dense, mid-high tussock grassland.

Mean no. native spp. per site: 13

Mean no. exotic spp. per site: 11 (46%)

Dominant native species: *Themeda australis*, *Juncus filiformis*, *Rumex brownii*, *Eryngium rostratum*, *Carex inversa*.

Indicator native species: *Themeda australis*, *Juncus filiformis*, *Drosera peltata*.

Exotic species: *Acetosella vulgaris*, *Hypochaeris radicata*, *Bromus hordeaceus*, *Vulpia myuros*, *Cirsium vulgare*, *Aira elegantissima*, *Briza minor*, *Moenchia erecta*, *Plantago lanceolata*.

Landform, geology and soils: Occurs on gentle slopes or flats on either granite or sediments/volcanics substrate forming loamy clay soils. Sites are often moist indicated by the prevalence of *Juncus filiformis*.

Distribution: Low elevation section of the tableland in the ACT.

Condition: High weed content, low native species diversity.

Threats and conservation status: Most sites are threatened by urban development and further weed invasion. Sites 337 and 368 are in ACT urban parkland.

Key sites for conservation: Site 364, 2CY Tower ACT; site 367, Airport Beacon which contains three threatened fauna species (S. Sharp pers. comm.).

• **Community 3. *Themeda australis*–*Poa sieberiana*–*Chrysocephalum apiculatum*–*Acaena ovina* tall grassland** (Figures 5, 6 and 7)

No. sample sites: 17 (excluding site 367).

Structure: Dense, tall tussock grassland.

Mean no. native spp. per site 20

Mean no. exotic spp. per site 9 (33%)

Dominant native species: *Themeda australis*, *Poa sieberiana*, *Chrysocephalum apiculatum*, *Acaena ovina*, *Leptorhynchus squamatus*, *Plantago varia*, *Asperula conferta*, *Danthonia laevis*, *Elymus scaber*, *Carex inversa*.

Indicator native species: This relatively heterogeneous community falls into two subgroups (3a and 3b). Subgroup 3a is distinguished by containing *Dodonaea procumbens*, *Swainsona sericea*, *Pimelea curviflora*, *Vittadinia muelleri*, *Stipa scabra* subsp. *falcata* and *Stipa nodosa*. Subgroup 3b is distinguished by the presence of *Ranunculus lapaceus*, *Geranium retrorsum*, *Lomandra multiflora*, *Senecio quadridentatus*, *Carex inversa*, *Geranium solanderi* and *Leptorhynchus squamatus*.



Figure 5. A travelling stock reserve near Black Lake east of Bombala dominated by a summer growth of *Themeda australis*. This species and other palatable plants were found to be most abundant in fenced off and lightly grazed areas such as churches, cemeteries, TSRs and rail easements.

These floristic differences indicate that Community 3a contains species more adapted to well drained sites than Community 3b.

Exotic species: *Trifolium glomeratum*, *Trifolium arvense*, *Trifolium campestre*, *Vulpia myuros*, *Tragopogon dubius*, *Hypochaeris glabra*, *Hypochaeris radicata*, *Cerastium glomeratum*, *Bromus hordeaceus*.

Landform, geology and soils: Community 3a occurs on well drained slopes or ridges on sediments or volcanic substrates forming red clay soils. The two Bredbo sites (355 and 358) are situated on tilted shales with shallow soils. Community 3b occurs in a variety of positions in the landscape, on mixed substrates and different soil types, although grey clay was recorded as the most common soil.

Distribution: Low to high altitudes mainly on the tableland tract. This is the most widespread of the eight communities, ranging from Kambah near Canberra in the north to near Bombala in the south and Adaminaby in the west. It occurs at a range of altitudes (550–1100 m).

Condition: Excluding the montane communities 6 and 7, the sites in this community were deemed to be in good condition. They contained a relatively low percentage of exotic species and a high diversity

of native plants. It would appear that sites dominated by *Themeda australis* have been less intensively grazed, at least over recent times.

Threats and conservation status: Most of these sites are fenced off from stock for one reason or another. Some such as TSRs are subject to intermittent grazing, others such as the Beloka and Round Plain cemeteries are subjected to occasional mowing. The main threats are increased grazing pressure and further weed invasion. Site 354 in the Yaouk Valley is threatened by cultivation. None of the grassland areas of this community are protected in conservation reserves. Previously forested grassland containing a similar species composition to this community is located in the Naas and Grassy Creek sections of Namadgi National Park in the ACT (unpublished site data F. Ingwersen pers. comm.).

Key sites for conservation: With the exception of site 345, Slacks Plain, all of these sites are worthy of protection. The most important sites are: sites 355 and 358 at Bredbo that contain populations of the rare *Dodonaea procumbens*; sites 352, 357 and other areas at Adaminaby which contain populations of the rare *Discaria pubescens*; site 354 at Yaouk which contains a high species diversity; sites 353 and 360 along the abandoned Queanbeyan railway line which contain the largest known populations of the endangered *Swainsona recta*.



Figure 6. The Queanbeyan–Cooma abandoned railway easement contains patches of *Themeda australis* grassland and the largest known population of the endangered forb *Swainsona recta* (site 353).



Figure 7. *Themeda australis* growing on private land east of Adaminaby (site 352). Several adjacent TSRs also contain grassland in relatively natural condition.

• **Community 4.** *Poa sieberiana*–*Acaena ovina* grassland on basalt, southern Monaro (Figure 8)

No. sample sites: 7

Structure: Dense, mid–high tussock grassland.

Mean no. native spp. per site 14

Mean no. exotic spp. per site 10 (42%)

Dominant native species: *Poa sieberiana*, *Acaena ovina*, *Asperula conferta*, *Bothriochloa macra*, *Danthonia caespitosa*, *Scleranthus diander*, *Psoralea tenax*, *Stipa bigeniculata*, *Wahlenbergia communis*.

Indicator native species: *Poa sieberiana*, *Psoralea tenax*, *Scleranthus diander*.

Exotic species: *Poa bulbosa*, *Vulpia myuros*, *Trifolium striatum*, *Trifolium campestre*, *Salva verbenacea*, *Petrorhagia nanteuilii*, *Hypochaeris radicata*.

Landform, geology and soils: Occurs on an undulating plateau composed of basalt which has weathered to form deep, chocolate/chernozem soils.

Distribution: This is the dominant vegetation community on the extensive basalt plateau situated on

the high tableland section of the study area between Cooma and Bombala. Maximum elevations extend to 1100 m (montane). Approximately 80 000 hectares of this area is covered with this semi-natural tussock grassland.

Condition: Moderate numbers of native species; all sites with a mixed native/exotic species cover occupying the inter-tussock space.

Threats and conservation status: The region where this community occurs is grazed by sheep and cattle and there has been some improvement of pasture — particularly by sowing clover species. The quadrat data suggest that TSRs have a higher native species richness than private land. Overgrazing of TSRs remains the major threat. No sites are protected in conservation reserves.

Key sites for conservation: Based on floristic composition it is difficult to single out any of the sites for special conservation action. All sites are valuable for conserving representative samples of this community. A number of the TSRs could be protected by reservation or conservation agreement (see Table 3).

• **Community 5.** *Stipa scabra* subsp. *falcata*–*Stipa bigeniculata* grassland (Figure 9)

No. sample sites: 10

Structure: Mid-dense, tall tussock grassland.

Mean no. native spp. per site: 13

Mean no. exotic spp. per site: 9 (43%)

Dominant native species: *Stipa scabra* subsp. *falcata*, *Stipa bigeniculata*, *Elymus scaber*, *Danthonia caespitosa*, *Enneapogon nigricans*, *Wahlenbergia communis*.

Indicator native species: *Stipa scabra* subsp. *falcata*, *Stipa bigeniculata*, *Stipa blackii*, *Danthonia linkii* subsp. *linkii*.

Exotic species: *Trifolium arvense*, *Vulpia myuros*, *Hypochaeris glabra*, *Hypochaeris radicata*, *Carthamus lanatus*, *Paronychia brasiliensis*, *Aira caryophylla*.

Landform, geology and soils: Mainly on upper slopes and ridges with well drained, sandy or loamy clay soils derived from granite, limestone and sediments.

Distribution: Occurs on rolling downs below the basalt plateau on the tableland tract in the Dalgety-Berridale region. Outlying sites occur on limestone at Quidong near Dalgety and on the southern outskirts of Canberra.

Condition: Most sites have been heavily grazed and contain moderate numbers of native plants

and high numbers of exotics. *Themeda australis* may have been more common before European settlement but is now largely absent.

Threats and conservation status: Pasture improvement and overgrazing threatens the remaining remnants. Site 377 (Symonston) in the ACT is threatened by urban development and is large in area and worthy of protection.

• **Community 6.** *Poa* spp–*Geranium antrorsum*–*Scleranthus biflorus*–*Leptorhynchus squamatus*–*Ranunculus graniticola* montane, sod tussock grassland (Figure 10)

No. sample sites: 7

Structure: Dense, mid-high, sod-tussock grassland.

Mean no. native spp. per site: 27

Mean no. exotic spp. per site: 2 (6%)

Dominant native species: *Poa sieberiana*, *Poa costiniana*, *Geranium antrorsum*, *Scleranthus biflorus*, *Leptorhynchus squamatus*, *Ranunculus graniticola*, *Acaena ovina*, *Oreomyrrhis argentea*, *Craspedia coolaminica*, *Podolepis robusta*.

Indicator native species: All of the above excluding *Poa sieberiana*, *Leptorhynchus squamatus*,



Figure 8. North Brother TSR (site 342). *Poa sieberiana* dominated grassland (Community 4) is confined to the high basalt plateau between Cooma and Bombala.



Figure 9. Bukalong roadside (site 371). The *Stipa scabra* subsp *falcata*–*Stipa bigeniculata* community (Community 5) occurs on better drained and less fertile soils than Community 4. It is likely that *Themeda australis* would have been common in this community before European settlement.



Figure 10. Long Plain (Site 413). The montane/subalpine grasslands (communities 6 and 7) growing in humus soil in frost hollows on the eastern side of Kosciusko National Park contain flora distinct from that present in the grasslands on the tableland tract (see Figure 2).

Acaena ovina. Also, *Microseris lanceolata*, *Wahlenbergia densifolia*, *Danthonia nudiflora*.

Exotic species: Few exotic species were recorded from this community: the most common were *Acetosella vulgaris*, *Hypochaeris radicata*, *Cerastium fontanum* subsp. *trivale*.

Landform, geology and soils: Occurs on valley flats or adjoining gentle slopes affected by cold air drainage; on granite or sedimentary substrates; soils are humus podsollic or peaty, formed under a high rainfall, cold temperature climatic regime.

Distribution: Between 1300–1400 m in the montane, south-western section of the study area.

Condition: Although these valleys were grazed over the last century, there was little pasture improvement and the grasslands are in excellent condition with few exotic species present.

Threats and conservation status: Large areas of this community are represented in Kosciusko National Park.

Key sites for conservation: Site 411 situated on Snowy Plain is outside the Park. In terms of its condition, the whole of the Snowy Plain is worthy of addition to the Park.

• **Community 7. *Poa costiniana*–*Epilobium billardierianum* subsp. *cinereum*–*Brachycome scapigera*–*Asperula gunnii* montane, sod-tussock grassland**

Sample sites: 3

Structure: Dense, mid-high sod-tussock grassland.

Mean no. native spp. per site: 27

Mean no. exotic spp. per site: 4 (12%)

Dominant native species: *Poa costiniana*, *Epilobium billardierianum* subsp. *cinereum*, *Brachycome scapigera*, *Asperula gunnii*, *Geranium retrorsum*, *Stylidium graminifolium*, *Wahlenbergia multiflora*.

Indicator native species: The above listed species and *Craspedia jamesii*, *Restio australis*, *Cardamine paucijuga*.

Exotic species: *Hypochaeris radicata*, *Acetosella vulgaris*, *Trifolium repens*, *Cerastium fontanum* subsp. *trivale*.

Landform, geology and soils: In wetter areas than Community 6, on valley flats affected by cold air drainage; on humus or peaty soils.

Distribution: Occurs in the same regions as Community 6.

Condition: Contains more weeds than Community 6 but is also in excellent condition.

Threats and conservation status: Well conserved in Kosciusko National Park.

• **Community 8. *Poa labillardieri* tall tussock grassland** (Figure 11)

No. sample sites: 6

Structure: Dense, very tall tussock grassland.

Mean no. native spp. per site: 7

Mean no. exotic spp. per site: 8 (52%)

Dominant native species: *Poa labillardieri*, *Carex appressa*, *Carex inversa*.

Indicator native species: Species listed above and *Juncus filiformis*, *Haloragis heterophylla*, *Hydrocotyle peduncularis*.

Exotic species: *Poa pratensis*, *Rumex crispus*, *Trifolium repens*, *Trifolium dubium*, *Cirsium vulgare*, *Holcus lanatus*.

Landform, geology and soils: Restricted to drainage lines or river flats on a range of substrates; soils generally loamy.

Distribution: Tableland and montane sections of the study area at a range of altitudes (740–1300 m). Widespread but restricted in extent where it occurs.

Condition: Poor condition; exotic species outnumber native species.

Threats and conservation status: Nutrient increases due to the application of agricultural fertilisers probably encourages weed invasion. No sites sampled are considered worthy of protection. All are on private land.



Figure 11. Joes Swamp (site 406). All sites sampled in Community 8 dominated by tall tussocks of *Poa labillardieri* contained a high proportion of exotic plants and low native plant diversity. This community is confined to drainage lines and river flats in the study area.



Figure 12. A healthy population of the rare plant *Discaria pubescens* occurs in the lightly grazed Round Plain Uniting Church (site 361) and near Adaminaby (site 352 and adjacent TSRs).

Nationally rare or threatened species

The following five species recorded in the survey are currently listed on ROTAP (Briggs and Leigh in prep.).

- *Swainsona recta* (3ECi): Approximately 1000 plants (J. Briggs pers. comm.) of this species have been counted in *Themeda australis* grassland (Community 3b) along a 22.5 km section of the abandoned Queanbeyan to Cooma railway easement between Tuggeranong in the north and south of Williamsdale in the south (including areas sampled in sites 353 and 360). This represents the largest known population of *Swainsona recta*, which is apparently restricted to grey loamy clay in the study area, as it has not been recorded in similar grassland on red clay further south. A small population also occurs in Canberra and several hundred plants grow near Wellington on the Central Western Slopes of NSW. In October 1993 less than 100 plants were observed in the vicinity of site 353 (J. Briggs pers. comm.). The rail easement population is threatened by grazing by stock, herbivorous invertebrates and by weed invasion. Fire may also play a role in its survival by removing the rank growth of grasses, stimulating resprouting from rootstock or the germination of seed. The railway easement is no longer regularly burnt as it was prior to its closure in 1987 (Zich 1993a). A rare grasshopper, *Keyacris scurra* is also present at this site.
- *Rutidosia leptorhynchoidea* (3ECa): This species was once widespread in Victoria (Department of Conservation and Environment 1993a) and in the ACT–Queanbeyan region of NSW. Many populations, have recently been destroyed by urban expansion (Zich 1993b). Over 1000 plants are known from the two hectare Queanbeyan Nature Reserve but a larger population exists at site 336, in Community 1, at the north-western foot of Mount Jerrabomberra. This site is also threatened by urban development.
- *Dodonaea procumbens* (3V): This species was added to the national list due, in part, to the findings of this survey. It is distributed (West 1984) from the Lofly Ranges of South Australia, where small roadside populations remain, to the Penola and Grampians areas of Victoria where it is considered rare (J. Briggs pers. comm.) and to the Monaro in NSW where it has only been collected on the tilted shale bands running north from Bredbo. Here it grows in *Themeda australis*–*Poa sieberiana* grassland (Community 3a, Sites 355, 358).
- *Calotis glandulosa* (3VC-): The seven collections of this species in the NSW National Herbarium reveal that this species is mainly restricted to grasslands on the Monaro, with outlying collections at Oberon on the Central Tablelands and Mount Imlay on the South Coast. The accuracy of J.C. Boorman's 1916 record on Mount Imlay requires confirmation given that recent surveys have not located it in its vicinity (Keith and Sanders 1990). *Calotis glandulosa* was located once during this survey at site 356, Beloka Cemetery, in a *Themeda australis* dominated grassland protected from grazing (Community 3a). *Calotis glandulosa* has also been recently recorded from Bibbenluke Cemetery between Nimmitabel and Bombala (I. Lunt pers. comm.) and along the Dalgety–Jindabyne Road easement (G. Harden pers. comm.). These latest recordings suggest this species may be more common than previously thought, although it is notable that it tends to be restricted to areas where grazing is largely excluded. It therefore appears that grazing by stock may have led to a decline in abundance of *Calotis glandulosa* throughout its range.
- *Discaria pubescens* (3RCa): This species has a widespread distribution from Queensland to Victoria. It appears to decline with grazing pressure and seed-

lings are rarely found (Department of Conservation and Natural Resources 1993b). It was recorded in two quadrats, 352 Adaminaby Hill (Figure 12) and 361 Round Plain Church. It is also known to occur in the TSRs at Adaminaby adjoining site 352. All sites where *Discaria pubescens* is recorded were fenced off from stock and are likely to have had a history of less intense or less frequent grazing. Herbarium records reveal this species is conserved in Kosciuszko and Namadgi National Parks.

Wahlenbergia densifolia, previously listed as a rare species on the national list, was in five of the eight sites in Kosciuszko National Park where it is under no threat and well conserved. It has therefore been removed from the ROTAP list (Briggs and Leigh in prep.).

Regionally rare species

Since the grassland ecosystems on the Monaro have been subject to major alteration since European settlement and little remains in good condition, it is logical that many grassland plant species would have declined in abundance during the same period. This particularly applies to inter-tussock, palatable forb species that have an upright habit (McIntyre 1993).

While 53 native species were recorded only once in the survey (Appendix 1) the vast majority of these are known to be common over their recorded range or common in other habitats. These include *Centrolepis strigosa*, *Podolepis hieracioides*, *Leptorhynchos elongatus*, *Swainsona behriana*, *Poa petrophila*, *Dichanthium sericeum*, *Dichelachne rara*, *Stipa blackii* and *Stipa densifolia*.

Species deemed to be regionally rare on the Tableland tract of the Monaro are *Diuris punctata*, *Swainsona monticola*, *Swainsona behriana*, *Stipa blackii*, *Senecio velleioides*, *Ranunculus sessiliflorus* var. *sessiliflorus*, *Podolepis hieracioides*, *Leptorhynchos elongatus* and *Solenogyne dominii*. Further surveys would refine this list.

This listing excludes species recorded in communities 6 and 7 that are located at higher elevations mainly in Kosciuszko National Park. It is based on the frequency of each species recorded in this survey, herbarium records for the area and the author's knowledge of other habitats on the Southern Tablelands.

Discussion

The hypothesis of Cabbage (1909) to explain the geographical distribution of natural grassland on the Monaro is largely supported by Ripley (1992) who states that grasslands throughout the world occur on a variety of substrates and landscapes but share the climatic characteristics of being subject to periodic drought and occurring in regions with a precipitation of between 350–800 mm. Titlyanova et al. (1990) add that the distribution of grassland is largely determined by the amount of available moisture in the soil. The lower altitude grasslands on the rainshadow-affected tableland tract of the Monaro fit with these findings.

The great prairie grasslands of North America and Russia grow on heavy chernozem soils, in low rainfall zones subject to drought (Moore 1964). Moisture availability in these heavy soils for the growth of trees is critical during dry times. Similar conditions prevail on the basalt plateau on the southern Monaro where *Poa sieberiana* is dominant (Community 4). A thick carbonate horizon is often present in these chernozem soils at less than 1 m depth (Costin 1954 and pers. comm.). This suggests

that water does not percolate to a great depth. Given the low rainfall for this area, it is likely that the available moisture in the top layer of soil is exhausted by the dense herbaceous vegetation and tree seedlings may be outcompeted by a dense sward of grasses and forbs. When trees do grow they tend to occupy rocky ridges where ground vegetation is more sparse and where their roots can penetrate through cracks in rocks to the water table.

Some wetter parts of the Monaro grasslands may be subject to gradual recolonisation by shrub and tree species that survived the dry conditions of the last ice age in refuge areas, such as the coastal plain and escarpment (A. Costin pers. comm.). The montane and subalpine sod-tussock grasslands of Kosciusko National Park receive high precipitation and are less prone to drought. Tree growth is restricted in this area by frequent frosts and competition of tree seedlings with forbs and grasses (Harwood 1976).

Of the eight grassland groups described, communities 1, 2 and 3 (mostly occurring below 1000 m) appear to be most similar in species composition to the grasslands on the basaltic western plains of southern Victoria (based on comparisons in McDougall and Kirkpatrick 1993 and the discussion in Willis 1964).

The Monaro grasslands today

With the exception of the montane, sod-tussock grasslands (Communities 6 and 7) the grassland communities on the Monaro have been substantially modified since European settlement. Exotic species comprise over 35% of the flora in most places. It appears that many native plants have been eliminated or reduced in abundance through a history of intense grazing, competition with weeds and perhaps altered fire regimes. Although at most sites the bulk of the vegetation is composed of a small number of dominant native species, there is now an abundance of introduced annual species such as *Vulpia* occupying the inter-tussock space. Similar trends have been documented for other regions — Moore (1953) for inland NSW, and Barr and Cary (1992) for Victoria.

It is estimated that only a small fraction of the original extent of communities 1,2,3 and 5 remain in reasonable condition, that is, have a range of native species providing most of the biomass. The best remnants occur on roadsides, in church yards, cemeteries and in Travelling Stock Reserves. A shared feature of these places is that they have been fenced off from continual grazing and have not been subject to intensive pasture improvement or cropping. Similar findings have been documented for grasslands in Victoria (Stuwe 1986, McDougall et al. 1993).

Environmental determinants of communities

While altitude is the major determinant in the distribution of most species and the vegetation communities, the tall tussock *Poa labillardieri* grassland (Community 8) occurs at a range of altitudes and on a number of substrates. The main factor determining its distribution is landform position, since it is confined to drainage lines or river flats. These locations are moister than the surrounding slopes and probably act as nutrient drains and therefore provide a suitable habitat for many introduced plants which favour moist, higher nutrient sites (Doing 1972).

Most of the Monaro grasslands occur on heavy textured soils derived from fine grained sediments or volcanics, basalt or limestone. The sites grouped under Community 3 cover the greatest variation in substrate, soils and altitude. Their grouping is largely due to a shared dominance of *Themeda australis* and *Poa sieberiana*, and the common presence of other grass and forb species such as *Geranium solanderi* and

Stackhousia monogyna. The presence of a high diversity of inter-tussock forbs, many with an upright habit, may indicate a history of light (or at least intermittent) grazing at these sites. *Themeda australis* can quickly respond to summer rainfall and proliferates when grazing is excluded but does not withstand continued heavy grazing (Vickery 1961). Moore (1959) considers *Themeda australis* was dominant on much of the Tablelands in New South Wales, including the Monaro, prior to European settlement. It is also postulated to have been more widespread in the lowland grasslands of southern Victoria (McTaggart 1936, Barr & Cary 1992). During the initial stages of settlement on the Monaro, Lhotsky (1835) noted *Themeda* as abundant. It may have been a codominant with species of *Stipa* in Community 5 which is restricted to sandier soils derived from granite and sediments. This supposition is supported in Hancock (1972), quoting from the landholder Crisp, who refers to the changes in condition of grassland in the late 19th century at Jimenbuan, a settlement 25 km south of Dalgety situated on granite:

Free selection and the introduction of sheep put an end to extensive raising of cattle because of the loss of water in the main creek and because the best grasses for cattle disappeared and made way for a finer and, in my opinion, less nourishing grass. I have seen kangaroo grass, when in seed, like a field of wheat three feet high. This disappeared.

The results of the extensive trials of the water requirements of agricultural plants undertaken by Shantz and Piemeisel (1927) showed that plants with the C3 photosynthetic system are better adapted in terms of water use efficiency, to cold temperatures and winter rainfall, while the malate-transporting C4 plants are more efficient with summer rainfall and warmer temperatures. *Themeda australis*, which is a C4 species, is probably not as well adapted photosynthetically to growing on the high basalt plateau south of Cooma (Community 4) as are the *Poa* species. *Themeda australis* does, however, exhibit a range of tolerances and other adaptations to the environment; indeed some ecotypes can grow in winter (Waterhouse 1993) and Groves (1975) found that separate populations contain varying flowering responses in relation to adaptations to different temperature regimes. *Themeda australis* may have existed in Community 4 as an inter-tussock subdominant before European settlement, if so it is now uncommon and must have been grazed out or outcompeted by *Poa* due to some unsubstantiated cause. *Poa sieberiana*, which is a C3 plant, is likely to have been a dominant in Community 4 at the time of European settlement as it is now. Conversely, *Themeda australis* may have adaptive advantages over *Poa sieberiana* at lower altitudes, such as in the vicinity of Dalgety or Bredbo, where the temperatures are warmer, soils are more permeable and drought more intense. *Themeda australis* may out-compete other species in these warmer climes in the absence of continuous grazing by its ability to respond quickly to summer rainstorms. The classification of Chan (1980) which lists eight grassland associations in the ACT would appear to fit as subdivisions under Community 1 (*Danthonia* dominated) and Community 2 (dominated by *Themeda australis* and *Bothriochloa macra*) derived in the present survey.

The results of the present survey suggest that the *Stipa scabra*-*Stipa bigeniculata* alliance mapped by Costin (1954) contains several distinct communities: Community 3, dominated by *Themeda australis* occurs mostly on sedimentary substrates in places such as Beloka, Bredbo and Adaminaby. Community 5, which is dominated by *Stipa scabra* subsp. *falcata* and *Stipa bigeniculata* occurs on sediments or granite near Cooma, Berridale and Dalgety, while the most distinctive and easily mappable unit, Community 4 (*Poa sieberiana*), covers the vast majority of the high basalt terrain. All of these communities contain *Stipa* species, which may explain their lumping by Costin (1954) at the alliance level. It may be better to redefine Costin's alliance as a *Poa sieberiana*-*Stipa scabra* subsp. *falcata*-*Stipa bigeniculata*-*Themeda australis* alliance.

Impact of grazing on plant communities

Differing grazing regimes may explain some of the differences between communities 3 and 5 on one hand, and communities 1 and 3 on the other. *Themeda australis* may have been largely eliminated from communities 1 and 5 leaving a dominance of hardier *Danthonia* and *Stipa* spp. respectively. It is possible, however, that *Danthonia* was always a major component of Community 1 (Edwards 1993). Therefore, it may be simplistic to describe the communities dominated by *Stipa* and *Danthonia* as 'disclimax' as suggested by Costin (1954), as these genera may have always have been abundant.

Because of the palatability of *Themeda australis*, sites where it is recorded as abundant are deemed to have a history of light grazing and therefore assessed as being in good condition. This includes most of the sites in Community 3 located in TSRs, railway easements, churchyards and cemeteries. Groves et al (1973) found that *Poa labillardieri* outcompeted *Themeda australis* in uptaking phosphorous and nitrogen when both species were grown together in pots. *Poa labillardieri* was found to contain more surface roots than *Themeda* which gave it an advantage in absorbing fertiliser nutrients from the topsoil. If it is assumed the same findings would apply to *Poa sieberiana*, then the widespread use of superphosphate on the Monaro may have advantaged *Poa sieberiana* over *Themeda australis* in communities 2-5. However, the previous discussion about the physiological advantage of the C3 *Poa* over the C4 *Themeda* under certain climatic regimes may provide a better explanation for the dominance of the former over the latter in Community 4, which occupies a region with low temperatures and naturally high nutrient soils. It is possible, however, that Community 3 represents something similar to the 'original' grassland of the lower altitudes in the study area. This is supported by its wide distribution on various substrates with the main common factor being that most sites have been protected from continuous heavy grazing. This may explain why communities 1,2,3 and 5 share many forb species but community 3 contains a greater proportion of upright forbs such as *Microseris lanceolata*, *Podolepis hieracioides* and *Bulbine bulbosa*.

The montane grasslands (communities 6 and 7) were grazed for over 100 years (Hancock 1972) (Snowy Plain is still grazed by sheep) but they have not been subject to pasture improvement or cultivation, although some areas may have been top-dressed with superphosphate. This would explain their relatively natural condition compared to the other grasslands in the study area.

Other types of grassland are present in the understorey of woodlands but these were not sampled in this survey. A distinctive example is the very tall, tussock grassland dominated by *Chionochloa pallida*. This was rarely observed and seemed to be restricted to poorer soils on quartz-rich ridges dominated by *Eucalyptus pauciflora* south of Cooma.

Rare grassland species

In a study of grassy vegetation on the Northern Tablelands of NSW McIntyre et al. (1993) suggest that inconspicuous, widespread, sparsely distributed species may have been overlooked in rare species listings. For many forbs in grassland, sparseness appears to be a common feature. This is supported by the floristic site data in Appendix 1 where a large proportion of grassland species was recorded in less than 5% of all quadrats. However, some of these species are common in adjoining woodlands and forests. The rarity of species recorded in this Monaro grasslands survey, as presented in the results section, was judged by a combination of measures including herbarium records, survey records and expert opinion. Herbaceous species of the

Monaro are not considered to be under-represented on the national rare plant list (Briggs and Leigh in prep.). Rather, the grassland ecosystems in the region are threatened and this has longer term implications for the continual survival of widespread herbaceous species in one region of south-eastern Australia.

Cover ratings and exotic species in classification

Many exotic species have been dispersed across the Monaro landscape through pasture-improvement programs (Wilson 1968, Douglas n.d.), and do not necessarily reflect complete naturalisation patterns. Therefore, it is not surprising that the UPGMA classification in which they were excluded was considered superior to those analyses that included them. It also appears that cover rating data gave a better result than using presence/absence data only. Others disagree (Kirkpatrick 1993 and pers. comm.) and consider that because the extent of cover of many grassland species varies considerably over time and with the seasons, presence/absence data is more meaningful. As far as the Monaro grasslands are concerned, most of the dominant native species are perennial, not annual or ephemeral. Cover ratings provide more information on this aspect of the floristics of the grasslands. This may explain why using cover ratings appeared to improve floristic classification. One danger of relying only on analyses using cover ratings may be that they overemphasise the importance of frequency variation in a few dominant species at the expense of less common species.

The UPGMA analysis may have been superior to the TWINSPLAN analysis for the reasons outlined in Minchin (1987). Divisive classifications such as TWINSPLAN classify deductively, and errors may accumulate as divisions are made in the sorting strategy. UPGMA makes no such assumptions, and calculates directly a hierarchical classification from the association measure matrix.

Management of remnants

Most research on native grasslands has concentrated on the use of native grasses as feed for stock (Roberts 1990, Munnich et al. 1991). Comparatively little is known about how to manage native grasslands for their intrinsic value, although there has been some research on the impact of mowing (Chan 1980) and fire (Lunt 1990). A review of lowland grassland management in Victoria is provided by Lunt (1991) and Kirkpatrick (1991) comments on managing Tasmanian natural grassland remnants.

Disturbance in grasslands would have occurred prior to European settlement through grazing and digging by native animals and by way of fire. Disturbance results in inter-tussock space which provides space for recruitment or resprouting of forbs. The survival of some forbs depends on light availability at ground level (Lunt 1993). Leaf arrangement (rosette versus erect) may explain differential survival rates of species grazed by stock (McIntyre 1993).

One of the main challenges to native grassland management is to understand how to impose disturbance that succeeds in stimulating seed germination (or resprouting) of native forbs in the inter-tussock gaps, without increasing invasion by weeds.

Fire

Given the early accounts of burning of the grassland vegetation on the Monaro by Aboriginal people (see Flood 1980, p. 285), grasslands are likely to have adapted to these fire regimes. These may have consisted of occasional patchy, low intensity fires, although it is presumed wildfires would have occasionally swept through landscape.

In 1824 the botanist Allan Cunningham observed Aborigines burning the 'Isabella' grassy plain in Autumn (Havard 1936), the present-day site of Tuggeronong, south of Canberra. Little is recorded about changes in frequency or intensity of fire after European settlement. A recent dendrochronological study of old *Callitris glaucophylla* trees in the nearby lower Snowy River valley (Pulsford 1991) has pointed to an increase in frequency and intensity of fires since then.

If burning regimes did change after Europeans arrived, there could have been detrimental impacts on some native plant species. However, data is lacking to even allow generalisations to be drawn about appropriate fire regimes in grasslands, although Lunt (1991) suggests *Themeda australis* grasslands should be burnt every five years. There is evidence, however, that different fire regimes may be required to maintain the native species diversity at different sites (Lunt 1993). Also, the benefits of fire to native plant diversity may be overwhelmed by post-fire weed invasion if a site has already been invaded by introduced species (Lunt 1990). Fire, however, appears to be necessary for the survival of *Swainsona recta* in the remnant grassland beside the Queanbeyan–Cooma railway easement (J. Briggs pers. comm.). As stated above, this species may require regular burning to keep competing grass species in check and stimulate seed germination or resprouting. The current lack of burning along the easement may be adversely affecting its population.

Site 361 Round Plain TSR has been burnt regularly by local landholders (B. Jardine pers. comm.) and it was recorded in this survey as being in good condition and worthy of nature reserve status.

Grazing

In 1862, one of the principal graziers in the Cooma district, James Litchfield, warned of the need for owners of large holdings to avoid overstocking and argued against tilling the soil in the region (Hancock 1972). This advice is just as relevant today.

Implementing appropriate grazing regimes is likely to be just as complicated as working out fire management. Only very general recommendations can be made. Some grazing may be beneficial for some sites, particularly if it is intermittent and carried out in autumn when most flowering and fruiting have finished. Year round, intense grazing (high stock numbers) is likely to eliminate some native species based on the findings that some species (including rare species) only survive in fenced off, non-grazed areas. At some sites the elimination of grazing altogether may, over time, lead to a simpler flora. Observations during a 1993 visit to site 364 (2CY Tower) in the ACT, two years after it was surveyed and two years after light grazing was removed, suggest that *Themeda* has increased its dominance and inter-tussock species have decreased in abundance.

The need to control the noxious weed *Hypericum perforatum* (St. Johns Wort) further complicates grazing management of grasslands. Currently, the Rural Lands Protection Board manages this weed on TSRs by spraying it with a herbicide or subjecting it to heavy grazing in spring before it can set seed (W. Phillips pers. comm.). This management, if carried out over important grassland sites, could conflict with protecting conservation values. It is therefore suggested that if *Hypericum perforatum* occurs in an important grassland site it should be treated by careful spraying or by a biological control agent (one demonstrated not to adversely affect native *Hypericum* species), but not by intensive spring grazing. Also, spelling an area from grazing for several years appears to reduce the population of this weed (R. Good pers. comm.).

Conservation

Concern for the loss of native pastures has long been expressed. Maiden (1898) was alarmed at the loss of native grasses and the increased dominance of introduced non-palatable weeds. He advised that efforts should be made to preserve native grasses as they are adapted to the conditions that prevail in the region.

Until recent times little attention has been paid to protecting and managing grasslands in reserves. They have not held the same appeal as forests or wetlands. This may be one reason why the grasslands of south-eastern Australia are poorly represented in reserves (McDougall and Kirkpatrick 1993).

No reserves have specifically been established to protect temperate grasslands on the tableland tract of the Southern Tablelands of NSW. Only one 150 ha nature reserve (Derrimut) has been permanently reserved for the protection of a lowland grassland ecosystem in Victoria, a State that has carried out extensive surveys of its grasslands, and this reserve is threatened by surrounding industrial development (Criagie 1993). Tunbridge Nature Reserve is the only place that samples natural grassland in the midlands of Tasmania.

The only grasslands protected on the Monaro are the montane, subalpine and alpine grasslands in Kosciusko and Namadgi National Parks. These are very different from the grasslands on the tableland tract (Figure 2).

More intensive surveys of grasslands in the ACT (Hogg 1990) have resulted in a large number of conservation proposals for that area. Also, research on the distribution of several rare fauna species (Edwards 1989, Osborne et al. 1991, S. Sharp pers. comm.) has resulted in conservation priorities that do not necessarily correspond to the priorities set by analysing floristics. For example, the Airport Beacon site (site 367) in the ACT contains three threatened species of animals (S. Sharp pers. comm.) but on the basis of its flora was not considered to be as important as other *Themeda*-dominated sites in the study area. Furthermore, Yen (1993) has shown, from work in Victoria, that the priorities for conserving grassland invertebrates do not necessarily match priorities set for protecting grasslands based on vascular plant data. More research is needed to examine the relationships between flora and fauna in grasslands to assist with grassland conservation.

Few options remain for the conservation of the tableland tract grasslands on the Monaro, but conservation efforts will be made easier because of the public ownership of most of the better remnants. A total of 23 sites of scientific significance have been identified (Table 3). This list includes 16 of the 17 sites documented in Benson and Wyse Jackson (1993). Given their scarcity, there is a valid argument that the remaining native grassland patches in good condition should be protected in reserves or by caveats attached to the title of the land (Table 3).

Public land, including travelling stock routes, containing native grassland should not be sold off to private landholders or leased for continual grazing. TSRs contain some of the best examples of native grassland and should be managed for conservation as well as catering for the needs of travelling stock. Some TSRs warrant stronger protection, either through dedication as nature reserves, or by way of management agreements drawn up under conservation agreements between the Rural Lands Protection Board and the NSW National Parks and Wildlife Service (Table 3). Maffra Lake TSR contains a stand of Community 4 grassland (not sampled in this survey) and contains one of the most important wetlands on the Monaro (Benson and Jacobs 1994). Reserving this TSR as a nature reserve would therefore result in achieving two nature conservation objectives.

Table 3. Grassland sites of the Monaro of scientific significance (excluding sites in Kosciusko National Park)

Site	Location	Community	Prot.	Justification	Management
336	Foot of Mt Jerrabomberra	1	NR	T1,C,D,R	LG,
348	Navy Navigational Centre ACT	1	NR	T2,M,R	LG,M,W
364	2CY Tower, ACT	2	NR	T2,C,M,R	LG,W
367	Airport Beacon, ACT	2	NR	T2,M	LG,W
363	Numeralla Cemetery	3a	CA	C,M,D	M,W
355	Haere Mai, Bredbo	3a	NR	T,C,M,D,R	LG,R
358	Nianna, Bredbo	3a	NR	T,C,M,D,R	LG,R
356	Beloka Cemetery	3a	CA	T,C,M	M,W,R
352	Adaminaby Hill*	3b	NR	T,C,M,D,R	LG,W,R
354	Yaouk	3b	CA	C,M,D,R	LG
357	Adaminaby Saleyards TSR	3b	CA	C,M	LG,W
361	Round Plain Uniting Church	3b	CA	T,C,M	M,W,R
353	Rail easement, Royalla	3b	NR	T,D	F,W,R
359	Round Plain TSR	3b	NR	C,M,R	F
420	Black Lake TSR	3b	NR	C,M,R	LG,W
339	Avon Lake TSR	4	CA	C,M,R	LG
340	Bondo TSR	4	CA	C,M,R	LG
342	North Brother TSR	4	CA	C,M,R	LG
343	Rock Flat TSR	4	CA	C,M,R	LG
341	Ravensworth TSR	4	CA	C,M,R	LG
377	Symonston	5	CA	R	LG
411	Snowy Plain	6	NP	C	LG
NA	Maffra Lake TSR**	4	NR	C,M	LG

Notes.

* Reservation of site 352 should be extended to include TSR No. 12. Alternatively, the private land portion of this area could be protected by a Conservation Agreement.

** Maffra Lake provides an opportunity to protect both a grassland and an important wetland in a reserve.

Prot. = Protection mechanism: NR = nature reserve, CA = conservation agreement

NP = add to existing national park

Justification:

T1 = contains rare or threatened plant species

T2 = contains rare or threatened animal species

C = is in relatively good condition

M = is well fenced or easy to manage in other ways

D = contains a high diversity of native plant species

R = outstanding example of a plant community

Management:

LG = light intermittent grazing based on past land use

M = irregular mowing of site

F = fire may be required based on past land use

W = weed control of major concern

R = monitoring and research of populations of rare species

The preparation of a conservation program for the native grassland remnants of the Monaro, similar to that produced for grassy vegetation in Victoria by the Victorian Department of Conservation and Environment (1993c), would be a worthy objective.

Acknowledgements

The survey work was partly funded by the World Wide Fund for Nature to whom I am grateful. Their funding enabled the employment of Dr Michael Wyse Jackson (then of Trinity College, Dublin) who gave invaluable assistance during the field surveys. Dr Surrey Jacobs of the National Herbarium of NSW assisted with the field work, helped with the identification of grasses and commented on the text. Mr Ian Lunt also commented on the text. The selection of many grassland sites was made possible due to the cooperation of local expertise, notably: Mr Stuart Burge, District Agronomist, Department of Agriculture, Cooma, Mr Winston Phillips of the Cooma District Rural Lands Protection Board, Ms Sarah Sharp from the University of Canberra and Ms Isobelle Crawford. Mr Frank Ingwersen provided unpublished site data for Namadgi National Park. Mr John Briggs, Dr Richard Groves, Mr Dennis Garden, Dr Ted Edwards and Dr Alec Costin provided additional advice. Mr Ian Pulsford and Dr Andy Spate of the NSW National Parks and Wildlife Service provided a GIS output of the geology of the Monaro region. Special thanks go to Ms Elizabeth Ashby who assisted with data analysis and the preparation of figures. Ms Judy Scott and Mrs Lyn McDougall also assisted with the preparation of figures.

References

- Barr, N. & Cary, J. (1992) *Greening a brown land: the Australian search for sustainable land use*. (Macmillan Education Australia).
- Belbin, L. (1993) PATN Patern Analysis Package Version 3.5: Technical Reference. (CSIRO Division of Wildlife and Ecology: Canberra).
- Benson, J.S. & Wyse Jackson (1993) Grassland communities and significant grassland sites: the Monaro region. In K. McDougall and J.B. Kirkpatrick (1993) (eds.) *Conservation of lowland native Grasslands in south-eastern Australia*. (World Wide Fund for Nature: Sydney).
- Benson, J.S. & Jacobs, S.L.W. (1994) Plant communities of the Monaro lakes. *Cunninghamia* 3(3): 651-676.
- Briggs, J.D. & Leigh, J.H. (in prep.) Rare or threatened Australian plants. (Australia Nature Conservancy Agency: Canberra).
- Cabbage, R.H. (1909) Notes on the native flora of New South Wales, VII, Eastern Monaro. *Proc. Linn. Soc. NSW*, 34: 310-336.
- Cabbage, R.H. (1918) Notes on the native flora of New South Wales, X, The Federal Capital Territory. *Proc. Linn. Soc. NSW*, 43: 673-711.
- Chan, C.W. (1980) Natural grasslands in Canberra: their distribution, phenology and effects of mowing. MSc. Thesis. (Australian National University: Canberra).
- Costin, A.B. (1954) *A study of the ecosystems of the Monaro region of New South Wales with special reference to soil erosion*. (Government Printer: Sydney).
- Craigie, V. (1993) Derrimut Grassland Reserve - management issues. *Proc. workshop on management of Relic Lowland Grasslands*. (University of Canberra: Canberra).
- Department of Conservation & Environment (Victoria). (1993a) Button Wrinklewort *Rutidosia leptorhynchoides*. Action Statement No. 28 Flora and Fauna Guarantee. (Dept. Conservation & Environment: Melbourne).
- Department of Conservation & Environment (Victoria). (1993b) Hairy Anchor Plant *Discaria pubescens*. Action Statement No. 47 Flora and Fauna Guarantee. (Dept. Conservation & Environment: Melbourne).
- Department of Conservation & Environment (Victoria). (1993c) Draft conservation program for native grasslands and grassy woodlands in Victoria. (Dept. Conservation & Environment: Melbourne).

- Doing, H. (1972) Botanical composition of pasture and weed communities in the Southern Tableland region, south-eastern Australia. CSIRO Division of Plant Industry. Tech. Paper No. 30: Canberra.
- Douglas, H.D.A. (n.d.) Pastures for the Cooma District. Division of Plant Industry. (New South Wales Department of Agriculture: Sydney).
- Edwards, E.D. (1989) *Synemon plana: An endangered moth in Canberra*. (CSIRO Division of Entomology: Canberra).
- Edwards, E.D. (1993) Belconnen Naval Station. *Proc. workshop on the management of relic lowland grasslands*. (University of Canberra: Canberra).
- Faith, D.P., Minchin, P.R. and Belbin, I. (1987) Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio* 69: 57–66.
- Flood, J.M. (1980) *The moth hunters: Aboriginal prehistory of the Australian alps*. (Australian Institute of Aboriginal Studies: Canberra).
- Frawley, K.J. (1991) *The conservation of remnant woodland and native grassland in the ACT*. (Report to the National Parks Association of the ACT: Canberra).
- Groves, R.H. (1975) Growth and development of five populations of *Themeda australis* in response to temperature. *Australian Journal of Botany* 23: 951–63.
- Groves, R.H., Keraitis, K. & Moore, C.W.E. (1973) Relative growth of *Themeda australis* and *Poa labillardieri* in pots in response to phosphorous and nitrogen. *Australian Journal of Botany* 21: 1–11.
- Hancock, W.K. (1972) *Discovering Monaro: a study of man's impact on his environment*. (Cambridge University Press).
- Harden, G.J. (1990–1993) *Flora of New South Wales*. (New South Wales University Press: Kensington).
- Harwood, C.E. (1976) Ecological studies of timberline phenomena. PhD thesis (Australian National University: Canberra).
- Havard, W.L. (1936) *Allan Cunningham's journal of a tour onto Argyle, March–April, 1824*. (Canberra & District Historical Society).
- Hill, M.O. (1979) TWINSPAN — A FORTRAN program for arranging multivariate data in a two-way table by classification of individuals and attributes. (Cornell University: New York).
- Hogg, D. McC. (1990) The ecological resources of the ACT: a review of recent information. Report to the National Capital Planning Authority, David Hogg Pty. Ltd, Environmental Consultants.
- Jefferson, E.J., Lodder, M.S., Willis, A.J. & Groves, R.H. (1991) Establishment of natural grassland species on roadsides of southeastern Australia. In Sanders, D.A. & Hobbs, R.J. (eds.) *Nature conservation: the role of corridors*. (Surrey Beattie & Sons).
- Keith, D.A. & Sanders, J.M. (1990) Vegetation of the Eden region, south-eastern Australia: species composition, diversity and structure. *J. Vegetation Science* 1:203–232.
- Kirkpatrick, J.B. (1983) An iterative method for establishing priorities for the selection of nature reserves: an example from Tasmania. *Biol. Cons.* 25: 127–134.
- Kirkpatrick, J.B. (1991) *Tasmanian native bush: a management handbook*. (Tasmanian Environment Centre: Hobart).
- Kirkpatrick, J.B. (1993) Methods. In McDougall, K. & Parsons R.F. (eds.) (1993) *Conservation of lowland native grasslands in south-eastern Australia*. (World Wide Fund for Nature: Sydney).
- Kruskal, J.B. (1964) Nonmetric multidimensional scaling: a numerical method. *Psychometrika* 29: 115–129.
- Leigh, J.H. (1991) Pastoral value and production from native pastures. In P.M. Dowling & D.L. Garden (eds.) *Native grass workshop proceedings*, Dubbo NSW. (Wool Corporation: Melbourne).
- Lhotsky, J. (1835) *A journey from Sydney to the Australian Alps*. (Mitchell Library: Sydney).
- Lodge, G.M., McCormick, L.H., Dadd, C.P. & Burger, A.E. (1991) A survey of graziers and pasture management practices on the northern slopes of New South Wales. *NSW Agriculture & Fisheries Technical Bulletin* 43.
- Lunt, I.D. (1990) Impact of an autumn fire on a long-grazed *Themeda triandra* (Kangaroo Grass) grassland: implications for management of invaded, remnant vegetations. *Victorian Naturalist* 107: 45–50.
- Lunt, L.D. (1991) Management of remnant lowland grasslands and grassy woodlands for nature conservation: a review. *Victorian Naturalist* 108: 56–66.
- Lunt, I.D. (1993) A functional approach to understanding grassland management. *Proc. workshop on management of relic lowland grasslands*. (University of Canberra: Canberra).

- Maiden, J.H. (1898) *A manual of the grasses of New South Wales*. (Government Printer: Sydney).
- McRae, R. (1989) Vegetation provinces of Kosciusko National Park. (National Parks & Wildlife Service of New South Wales).
- McDougall, K. & Kirkpatrick, J.B. (eds.) (1993) *Conservation of lowland native grasslands in South-eastern Australia*. (World Wide Fund for Nature: Sydney).
- McDougall, K., Barlow, T. & Appleby, M. (1993) Western basalt plains, Lake Omeo, Murray Valley riverine plains and the Wimmera. In McDougall, K & Parsons R.F. (eds.) *Conservation of lowland native grasslands in south-eastern Australia*. (World Wide Fund for Nature: Sydney).
- McIntyre, S. (1993) Disturbance: Does it have a role in the maintenance of rare grassland species? *Proc. workshop management of relic lowland grasslands*. (University of Canberra: Canberra).
- McIntyre, S., Huang, Z. & Smith, A.P. (1993) Patterns of abundance in grassy vegetation of the New England Tablelands: identifying regional rarity in a threatened vegetation type. *Australian Journal of Botany* 41: 49–64.
- McTaggart, A. (1936) *A survey of the pastures of Australia*. (Council for Scientific & Industrial Research Bulletin 99. Commonwealth of Australia).
- Minchin, P.R. (1987) An evaluation of the robustness of techniques for ecological ordination. *Vegetatio* 69: 89–107.
- Moore, C.W.E. (1953) The vegetation of the south eastern Riverina, New South Wales I. The disclimax communities. *Aust. J. Bot.* 1: 485–547.
- Moore, C.W.E. (1953) The vegetation of the south eastern Riverina, New South Wales II. The disclimax communities. *Aust. J. Bot.* 1: 548–567.
- Moore, C.W.E. (1964) Distribution of grasslands. In Barnard, C. (ed.) *Grasses and grassland*. (MacMillan).
- Moore, R.M. (1959) Ecological observations on plant communities grazed by sheep in Australia. In *Biogeography and ecology in Australia* (Junk: The Hague).
- Munnich, D.J., Simpson, P.C. & Nicol, H.I. (1991) A survey of the native grasses in the Goulburn district and factors influencing their abundance. *Rangel. J.* 13: 118–129.
- Ollier, C.D. (1982) The Great Escarpment of eastern Australia: tectonic and geomorphic significance. *J. Geol. Soc., Aust.* 29: 13–23.
- Ollier, C.D. & Taylor, D. (1988) Major geomorphic features of the Kosciusko–Bega region, New South Wales. *J. Geol. Geophysics* 10: 357–362.
- Ollier, C.D. & Wyborn, D. (1989) Geology of alpine Australia. In Good, R.B. (ed.) *The significance of the Australian Alps*. (National Parks Liaison Committee: Canberra).
- Osborne, W.S., Lintermans, M. & Williams, K.D. (1991) Distribution and conservation status of the endangered Pink-eared legless Lizards *Aprasia parapulchella* Kluge. Research Report 5. (Dept. ACT Parks & Conservation Service: Canberra).
- Pryor, L.D. (1954) Plant communities. in White, H.L. (ed.) *Canberra —the Nation's capital*. (Angus & Robertson: Sydney).
- Pulsford, I.F. (1991) History of disturbance in White Cypress Pine (*Callitris glaucophylla*) forests of the lower Snowy River valley, Kosciusko National Park. M.Sc. thesis. (Australian National University: Canberra).
- Ride, W.D.L., Taylor, G., Walker, P.H. & Davis, A.C. (1989) Zoological history of the Australian alps —the mammal fossil-bearing deposits of the Monaro. In Good, R.B. (ed.) *The significance of the Australian Alps*. (National Parks Liaison Committee: Canberra).
- Ripley, E.A. (1992) Grassland climate. In Coupland, R.T. *Ecosystems of the world. 8A: natural grasslands: introduction and western hemisphere*. (Elsevier: Amsterdam).
- Roberts, B.R. (1990) Potential of native grasses and barriers of maximising their use. In P.M. Dowling & D.L. Garden (eds.) *Native grass workshop proceedings*, Dubbo, NSW. (Wool Corporation: Melbourne).
- Shantz, H.C. & Piemeisal, L.N. (1927) The water requirements of plants at Akron, Colorado. *J. Agricultural Research* 34: 1093–1190.
- Spate, A. (1993) Derived geological groups for the south-eastern region New South Wales. Unpublished. (National Parks & Wildlife Service of New South Wales: Queanbeyan).
- Stuwe, J. (1986) An assessment of the conservation status of native grasslands on the western plains, Victoria and sites of botanical significance. (Arthur Rylah Institute for Environmental Research, Technical Report Series No. 48).
- Titlyanova, A.A., Zlotin, R.I. & French, N.R. (1990) Changes in structure and function of tem-

- perate zone grasslands under the influence of Man. in Breymeyer (ed.) *Ecosystems of the world. 17a: managed grasslands regional studies* 301–334. (Elsevier: Amsterdam).
- Walker, J. & Hopkins, M.S. (1990) Vegetation. In *Australian soil and land survey field handbook* second edition (McDonald, D.C., Isbell, R.F., Speight, J.G., Walker, J. & Hopkins, M.S.). (Inkata Press: Melbourne).
- Waterhouse, D. (1993) The agricultural utilisation of grasslands and native grasses. *Proc. workshop on the management of relic lowland grasslands*. (University of Canberra: Canberra).
- West, J.G. (1984) A revision of *Dodonaea* (Sapindaceae) in Australia. *Brunonia* 7: 1–194.
- Willis, J.H. (1964) Vegetation of the basalt plains in western Victoria. *Royal Soc. Vic.* 77: 397–405.
- Wilson, B. (ed.) (1968) *Pasture improvement in Australia*. (Murray: Sydney).
- Wright, D.F. (1977) A site evaluation scheme for use in the assessment of potential nature reserves. *Biol. Cons.* 2: 293–305.
- Vickery, J.W. (1961) *Themeda*. Gramineae. *NSW Flora Series* 19 (1): 59–61.
- Yen, A. (1993) Some issues involved in the conservation of lowland native grassland invertebrates. *Proc. workshop on the management of relic lowland grasslands*. (University of Canberra: Canberra).
- Zich, F.A. (1993a) Species recovery plan: *Swainsona recta* A. Lee (Small Purple Pea). (New South Wales National Parks & Wildlife Service: Queanbeyan).
- Zich, F.A. (1993b) Species recovery plan: *Rutidosia leptorrhynchoidea* F. Muell. (Button Wrinklewort). (New South Wales National Parks & Wildlife Service: Queanbeyan).

Manuscript received 8 November 1993

Manuscript accepted 19 April 1994

Appendix 1. (cont.)

Species	Plant communities							Total
	1	2	3	4	5	6	7	8
<i>Carex breviculmis</i> (Cyperaceae)	—	—	—	—	—	14	—	2
<i>Carex canescens</i> (Cyperaceae)	—	—	—	—	—	14	—	2
<i>Carex inversa</i> (Cyperaceae)	20	67	47	37	40	—	—	37
<i>Carex longebrachiata</i> (Cyperaceae)	—	—	—	—	—	—	—	2
<i>Carthamus lanatus</i> * (Asteraceae)	—	—	—	25	30	—	—	8
<i>Celmisia astelifolia</i> (Asteraceae)	—	—	—	—	—	14	—	2
<i>Centaurium erythraea</i> * (Gentianaceae)	—	50	35	—	—	—	—	14
<i>Centrolepis strigosa</i> (Centrolepidaceae)	—	17	—	—	—	—	—	2
subsp. <i>strigosa</i> *	—	—	—	—	—	—	—	—
<i>Cerastium fontanum</i> (Caryophyllaceae)	—	—	6	—	—	14	67	8
subsp. <i>triviale</i> *	—	—	—	—	—	—	—	—
<i>Cerastium glomeratum</i> * (Caryophyllaceae)	—	33	17	12	—	—	—	11
<i>Chamaesyce drummondii</i> (Euphorbiaceae)	20	17	6	—	40	—	—	8
<i>Cheilanthes sieberi</i> (Sinopteridaceae)	20	—	6	—	—	—	—	3
subsp. <i>sieberi</i>	—	—	—	—	—	—	—	—
<i>Chloris truncata</i> (Poaceae)	—	—	—	—	10	—	—	2
<i>Chrysocephalum apiculatum</i> (Asteraceae)	80	33	82	75	30	—	—	47
<i>Chrysocephalum semipapposum</i> (Asteraceae)	20	—	12	—	—	—	—	5
<i>Cicendia quadrangularis</i> * (Gentianaceae)	—	17	—	—	—	—	—	2
<i>Cirsium vulgare</i> * (Asteraceae)	—	17	6	25	10	—	—	18
<i>Convolvulus erubescens</i> (Convolvulaceae)	60	17	47	75	40	—	—	35
<i>Coprosma nivalis</i> (Rubiaceae)	—	—	—	—	—	14	—	2
<i>Craspedia coolaminica</i> (Asteraceae)	—	—	—	—	—	86	—	10
<i>Craspedia jamesii</i> (Asteraceae)	—	—	—	—	—	—	67	4
<i>Crassula sieberiana</i> (Crassulaceae)	—	—	12	12	—	—	—	5
<i>Cryptandra amara</i> (Rhamnaceae)	—	—	6	—	—	—	—	2
<i>Cymbonotus lawsonianus</i> (Asteraceae)	40	17	12	—	10	—	—	10
<i>Cymbonotus preissianus</i> (Asteraceae)	—	—	—	—	—	—	—	5
<i>Cynoglossum suaveolens</i> (Boraginaceae)	20	17	6	—	—	14	67	5
<i>Dactylis glomerata</i> * (Poaceae)	—	—	—	—	10	—	—	5
<i>Danthonia auriculata</i> (Poaceae)	40	—	—	—	—	—	—	2
<i>Danthonia caespitosa</i> (Poaceae)	—	17	35	75	70	—	—	3
<i>Danthonia carphoides</i> (Poaceae)	80	17	6	—	—	—	—	32
<i>Danthonia laevis</i> (Poaceae)	—	—	29	12	30	14	—	10
<i>Danthonia linkii</i> var. <i>linkii</i> (Poaceae)	—	—	6	—	30	—	—	16
	—	—	—	—	—	—	—	6

Appendix 1. (cont.)

Species

	1	2	3	Plant communities		5	6	7	8	Total
				4						
<i>Festuca asperula</i> (Poaceae)	-	-	6	-	-	-	29	67	-	8
<i>Galium divaricatum</i> * (Rubiaceae)	20	-	6	-	-	-	-	-	-	3
<i>Geranium anthriscum</i> (Geraniaceae)	-	-	12	-	-	-	100	100	17	21
<i>Geranium retrorsum</i> (Geraniaceae)	-	-	29	-	-	-	-	-	33	11
<i>Geranium solanderi</i> (Geraniaceae)	-	-	35	12	-	-	-	-	-	11
<i>Glyceria australis</i> (Poaceae)	-	-	-	-	-	-	-	-	17	2
<i>Glycine clandestina</i> (Fabaceae)	-	-	23	-	-	-	-	-	-	6
<i>Glycine tabacina</i> (Fabaceae)	-	-	6	-	-	-	-	-	-	2
<i>Grapplethum americanum</i> * (Asteraceae)	-	-	6	-	-	-	-	-	-	2
<i>Grapplethum gymnocephalum</i> (Asteraceae)	-	-	6	-	10	-	29	33	-	6
<i>Gonocarpus tetragynus</i> (Haloragaceae)	-	17	6	-	-	-	-	-	-	3
<i>Goodenia pinnatifida</i> (Goodeniaceae)	100	33	18	37	-	-	-	33	-	21
<i>Hakea microcarpa</i> (Proteaceae)	-	-	12	-	-	-	-	33	-	5
<i>Halragis heterophylla</i> (Haloragaceae)	-	-	-	-	-	-	-	33	33	5
<i>Hedynopsis rhagadiolobides</i> (Asteraceae)	20	-	-	-	-	-	-	-	-	2
subsp. <i>cretica</i> *	-	-	-	-	-	-	-	-	-	-
<i>Helichrysium scorpioides</i> (Asteraceae)	-	-	6	-	-	-	-	33	-	3
<i>Hemarthria uncinata</i> (Poaceae)	-	-	-	-	-	-	-	-	17	2
var. <i>uncinata</i>	-	-	-	-	-	-	-	-	-	-
<i>Hirschfeldia incana</i> * (Brassicaceae)	-	-	-	-	10	-	-	-	-	2
<i>Holtus lanatus</i> * (Poaceae)	-	17	-	-	-	-	-	-	50	6
<i>Hordeum leporinum</i> * (Poaceae)	-	-	-	-	10	-	-	-	-	2
<i>Hovea purpurea</i> (Fabaceae)	-	-	-	-	-	-	14	-	-	2
<i>Hydrocotyle laxiflora</i> (Apiaceae)	20	-	6	-	-	-	-	-	-	3
<i>Hydrocotyle peduncularis</i> (Apiaceae)	-	-	-	-	-	-	-	33	33	5
<i>Hydrocotyle gramineum</i> (Clusiaceae)	20	33	23	12	-	-	-	33	-	13
<i>Hydrocotyle japonicum</i> (Clusiaceae)	-	-	-	-	-	-	-	-	-	2
<i>Hydrocotyle perforatum</i> * (Clusiaceae)	-	17	-	-	-	-	-	-	-	2
<i>Hypochoeris glabra</i> * (Asteraceae)	60	-	23	-	-	-	-	-	-	18
<i>Hypochoeris radicata</i> * (Asteraceae)	60	100	82	50	40	60	71	67	50	69
<i>Hypoxis hygrometrica</i> (Hypoxidaceae)	-	-	-	-	-	-	-	33	-	2
var. <i>hygrometrica</i>	-	-	-	-	-	-	-	-	-	-
<i>Isolepis cernua</i> (Cyperaceae)	-	-	-	-	-	-	-	-	17	2
<i>Juncus australis</i> (Juncaceae)	-	17	-	-	10	-	-	-	50	8
<i>Juncus bufonius</i> * (Juncaceae)	20	33	-	-	-	-	-	-	17	6
<i>Juncus capitatus</i> * (Juncaceae)	-	33	-	-	-	-	-	-	-	3

Appendix 1. (cont.)

Species	1	2	3	4	5	6	7	8	Total
<i>Juncus filicaulis</i> (Juncaceae)	—	83	—	12	—	—	33	50	16
<i>Lepidium africanum</i> * (Brassicaceae)	—	—	6	—	10	—	—	—	3
<i>Leptorhynchus elongatus</i> (Asteraceae)	—	—	—	12	—	—	—	—	2
<i>Leptorhynchus squamatus</i> (Asteraceae)	40	33	71	12	—	100	67	—	42
<i>Leptospermum lanigerum</i> (Myrtaceae)	—	—	—	—	—	—	33	—	2
<i>Leucopogon hookeri</i> (Epacridaceae)	—	—	—	—	—	43	33	—	6
<i>Limosella australis</i> (Scrophulariaceae)	—	—	—	—	—	—	—	17	2
<i>Linaria arvensis</i> * (Scrophulariaceae)	—	—	12	25	—	—	—	—	6
<i>Linaria pelisseriana</i> * (Scrophulariaceae)	20	—	6	—	—	—	67	—	3
<i>Linum marginale</i> (Linaceae)	—	—	—	—	—	—	—	—	3
<i>Lissanthe strigosa</i> (Epacridaceae)	20	—	—	—	—	—	—	—	2
<i>Lolium perenne</i> * (Poaceae)	20	—	—	—	10	—	—	17	5
<i>Lomandra filiformis</i> (Lomandraceae)	40	17	—	—	—	—	—	—	5
subsp. <i>filiformis</i>	—	—	—	—	—	—	—	—	—
<i>Lomandra multiflora</i> (Lomandraceae)	20	33	18	—	—	—	—	—	10
<i>Luzula densiflora</i> (Juncaceae)	—	17	23	—	—	—	—	—	8
<i>Luzula modesta</i> (Juncaceae)	—	17	—	—	—	—	—	—	2
<i>Luzula ovata</i> (Juncaceae)	—	—	6	—	—	71	33	—	11
<i>Medicago lupulina</i> * (Fabaceae)	—	—	6	25	—	—	—	—	5
<i>Medicago minima</i> * (Fabaceae)	—	—	6	25	—	—	—	—	5
<i>Medicago sativa</i> * (Fabaceae)	—	—	—	—	10	—	—	—	2
<i>Melichrus urceolatus</i> (Epacridaceae)	—	—	6	—	—	—	—	—	2
<i>Microseris lanceolata</i> (Asteraceae)	20	—	12	—	—	57	33	—	13
<i>Microtis unifolia</i> (Orchidaceae)	—	—	6	—	—	—	—	—	2
<i>Mirbella oxylobioides</i> (Fabaceae)	—	—	12	—	—	—	—	—	3
<i>Moenchia erecta</i> * (Caryophyllaceae)	80	17	12	—	20	—	—	—	14
<i>Muehlenbeckia axillaris</i> (Polygonaceae)	—	—	—	—	—	14	—	—	2
<i>Myosotis caespitosa</i> * (Boraginaceae)	—	—	—	—	10	—	—	—	2
<i>Myosotis discolor</i> * (Boraginaceae)	—	50	6	—	—	—	—	—	6
<i>Nassella trichotoma</i> * (Poaceae)	20	17	—	—	—	—	—	17	5
<i>Oenothera stricta</i> (Onagraceae)	—	—	6	—	—	—	—	—	2
subsp. <i>stricta</i> *	—	—	—	—	—	—	—	—	—
<i>Oreomyrrhis argentea</i> (Apiaceae)	—	—	—	—	—	57	—	—	6
<i>Oreomyrrhis eriopoda</i> (Apiaceae)	—	—	18	12	20	29	33	—	14
<i>Oxalis exilis</i> (Oxalidaceae)	—	17	12	—	30	14	33	—	13
<i>Oxalis perennans</i> (Oxalidaceae)	20	17	18	12	20	14	33	—	16

Appendix 1. (cont.)
Species

Species	Plant Communities								Total
	1	2	3	4	5	6	7	8	
<i>Ranunculus pumilio</i> (Ranunculaceae)	-	-	-	-	-	-	-	17	2
var. <i>pumilio</i>	-	-	-	-	-	-	-	-	2
<i>Ranunculus sessiliflorus</i> (Ranunculaceae)	-	-	6	-	-	-	-	-	2
var. <i>sessiliflorus</i>	-	-	-	-	-	-	-	-	2
<i>Restio australis</i> (Restionaceae)	-	-	-	-	-	-	33	-	2
<i>Rhodanthe anthemoides</i> (Asteraceae)	-	-	-	-	-	29	-	-	3
<i>Rhytidosporum alpinum</i> (Pittosporaceae)	-	-	6	-	-	29	-	-	5
<i>Rosa rubiginosa</i> * (Rosaceae)	-	17	18	12	-	-	-	17	10
<i>Rumex brownii</i> (Polygonaceae)	20	83	47	25	50	-	-	-	34
<i>Rumex crispus</i> * (Polygonaceae)	-	-	-	-	-	-	-	33	3
<i>Rutidosia leptorhynchoides</i> (Asteraceae)	20	-	-	-	-	-	-	-	2
<i>Salvia verbenaca</i> * (Lamiaceae)	-	-	18	62	40	-	-	-	19
<i>Schoenusapogon</i> (Cyperaceae)	20	50	23	-	-	-	33	-	14
<i>Scleranthus biflorus</i> (Caryophyllaceae)	-	-	18	-	10	100	67	-	21
<i>Scleranthus diander</i> (Caryophyllaceae)	-	-	18	62	20	-	-	-	16
<i>Senecio lautus</i> subsp. <i>alpinus</i> (Asteraceae)	-	-	-	-	-	57	-	-	6
<i>Senecio quadridentatus</i> (Asteraceae)	-	17	12	-	-	-	-	-	5
<i>Senecio velleioides</i> (Asteraceae)	-	-	-	-	-	19	-	-	2
<i>Solenogyne dominii</i> (Asteraceae)	-	-	-	-	30	-	-	-	5
<i>Solenogyne gunnii</i> (Asteraceae)	-	-	12	-	-	43	-	17	10
<i>Sonchus asper</i> (Asteraceae)	-	-	6	-	-	-	-	-	2
subsp. <i>glaucescens</i> *	-	-	-	-	-	-	-	-	-
<i>Spergularia rubra</i> * (Caryophyllaceae)	-	-	-	-	10	-	-	-	2
<i>Sphaerolobium vimineum</i> (Fabaceae)	-	-	-	-	-	-	33	-	2
<i>Stackhousia monogyna</i> (Stackhousiaceae)	-	-	28	-	-	-	-	-	8
<i>Stellaria angustifolia</i> (Caryophyllaceae)	-	-	-	-	-	-	33	17	3
<i>Stellaria multiflora</i> (Caryophyllaceae)	-	-	-	-	-	-	33	-	2
<i>Stipa bigeniculata</i> (Poaceae)	60	17	18	62	90	-	-	-	34
<i>Stipa blackii</i> (Poaceae)	-	-	-	-	20	-	-	-	3
<i>Stipa nodosa</i> (Poaceae)	-	-	18	25	10	-	-	-	10
<i>Stipa scabra</i> subsp. <i>falcata</i> (Poaceae)	20	-	23	12	90	-	-	-	24
<i>Styidium graminifolium</i> (Stylidiaceae)	-	-	12	-	-	14	100	-	35
<i>Swainsona behriana</i> (Fabaceae)	-	-	12	12	-	-	-	-	5
<i>Swainsona monticola</i> (Fabaceae)	-	-	6	12	-	29	-	-	6
<i>Swainsona recta</i> (Fabaceae)	-	-	12	-	-	-	-	-	3

Appendix 1. (cont.)

Species	1	2	3	Plant Communities			6	7	Total
				4	5				
<i>Swainsona sericea</i> (Fabaceae)	-	-	12	-	20	-	-	-	6
<i>Taraxacum officinale</i> * (Asteraceae)	-	-	6	-	-	14	-	-	8
<i>Themeda australis</i> (Poaceae)	20	100	100	37	20	14	33	-	50
<i>Trachymene humilis</i> (Apiaceae)	-	-	-	-	-	14	-	-	2
subsp. <i>humilis</i>									
<i>Tragopogon dubius</i> * (Asteraceae)	-	-	12	25	10	-	-	-	8
<i>Tragopogon porrifolius</i> * (Asteraceae)	-	-	6	-	10	-	-	-	3
<i>Tricoryne elatior</i> (Anthericaceae)	20	-	-	-	-	-	-	-	2
<i>Trifolium angustifolium</i> * (Fabaceae)	-	-	6	-	-	-	-	-	2
<i>Trifolium anvense</i> * (Fabaceae)	40	-	76	62	57	-	-	-	44
<i>Trifolium campestre</i> * (Fabaceae)	80	33	88	50	30	-	-	17	47
<i>Trifolium dubium</i> * (Fabaceae)	80	67	12	-	20	-	33	67	27
<i>Trifolium glomeratum</i> * (Fabaceae)	-	-	35	25	30	-	-	-	18
<i>Trifolium pratense</i> * (Fabaceae)	-	-	6	-	-	-	-	-	2
<i>Trifolium repens</i> * (Fabaceae)	-	-	23	12	-	29	67	33	18
<i>Trifolium striatum</i> * (Fabaceae)	-	-	29	87	20	-	-	-	23
<i>Trifolium subterraneum</i> * (Fabaceae)	80	50	12	-	40	-	-	17	23
<i>Triptilodiscus pygmaeus</i> (Asteraceae)	60	33	18	-	10	-	-	-	14
<i>Velleia paradoxa</i> (Goodeniaceae)	-	-	-	-	-	29	-	-	3
<i>Verbascum thapsus</i> (Scrophulariaceae)	-	-	6	12	10	-	-	-	5
subsp. <i>thapsus</i> *									
<i>Vaerbasicum virgatum</i> * (Scrophulariaceae)	-	17	18	-	-	-	-	-	6
<i>Veronica arvensis</i> * (Scrophulariaceae)	-	-	6	-	-	-	-	17	3
<i>Vaeronica calycina</i> (Scrophulariaceae)	-	-	6	-	-	-	-	-	2
<i>Viola betonicifolia</i> (Violaceae)	-	-	6	-	-	29	33	-	6
<i>Vittadinia cuneata</i> (Asteraceae)	-	-	17	25	10	-	-	-	10
var. <i>cuneata</i>									
<i>Vittadinia muelleri</i> (Asteraceae)	80	17	23	12	50	-	-	-	24
<i>Vulpia bromoides</i> * (Poaceae)	20	33	12	-	-	-	-	33	11
<i>Vulpia muralis</i> * (Poaceae)	20	-	-	-	-	-	-	-	2
<i>Vulpia myuros</i> * (Poaceae)	100	33	64	87	100	-	-	17	58
<i>Wahlenbergia communis</i> (Campanulaceae)	60	-	41	62	60	-	-	-	34
<i>Wahlenbergia densifolia</i> (Campanulaceae)	-	-	-	-	-	71	-	-	8
<i>Wahlenbergia gracilis</i> (Campanulaceae)	-	-	-	-	-	-	-	-	3
<i>Wahlenbergia multicaulis</i> (Campanulaceae)	20	-	23	-	20	-	100	-	13
<i>Wurmbea dioica</i> (Colchicaceae)	20	16	6	-	-	-	-	-	5

Plant communities of the Monaro lakes

J.S. Benson and S.W.L. Jacobs *Print 6652*

Benson, J.S. & Jacobs, S.W.L., (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, NSW, Australia 2000) 1994. *Plant communities of the Monaro lakes*. *Cunninghamia* 3(3): 651–676. Four wetland plant communities were defined from a cluster analysis of plant species recorded from 65 lakes in the southern Monaro region, Southern Tablelands of New South Wales (c. Lat. 36° 00'–37° 00' S Long. 148° 30'–149° 20' E). 110 plant species (including 19% exotic) were recorded from the lakes and their strandlines. Several species were collected for the first time on the Southern Tablelands. Altitude, size of lakes and permanence of water appear to be the main factors directly or indirectly determining floristic variation between the lakes, whereas substrate appears not to be important in this regard. We postulate that wave action on large lakes may limit the survival of floating-attached waterplants. Further study is required to establish the importance of lake size and shape, and salinity on species distribution. A number of lakes judged to be in sound condition or containing significant species are proposed for conservation.

Introduction

Over the last 25 years there have been a number of botanical, limnological and waterfowl surveys of wetlands in south-eastern Australia. Jacobs and Brock (1993) review the literature on wetland studies in southern (temperate) Australia and provide an assessment of the classification systems used. Other major contributions include a survey of the coastal saltmarsh plant communities in New South Wales by Adam et al. (1988), the review of wetlands in Victoria by Norman and Corrick (1988), the review of Tasmanian wetlands by Kirkpatrick and Tyler (1988), and the description of Tasmanian wetland plant communities by Kirkpatrick and Harwood (1983).

There is limited documentation of the waterplants growing on the Tablelands compared to the coastal wetlands in New South Wales. Exceptions include the peat swamps on the Southern Tablelands (Hope & Southern 1980), and a number of Northern Tablelands wetlands (Briggs 1976, Bell 1992) which are also subject to current research on the seedbank dynamics of wetland communities (Brock & Britton in press, M. Brock pers. comm.). The vegetation of the alpine and subalpine swamps in Kosciusko National Park were documented in Wimbush and Costin (1979a & b).

The aim of our survey was to record the waterplants growing in the lakes on the tableland tract of the southern Monaro region (Costin 1954), to classify the wetland plant communities, suggest possible explanations for the distribution of those plant communities and their constituent species, comment on the conservation status of the wetland communities, and make suggestions on how to improve conservation.

The study area

The survey concentrated on the near-permanent (rarely dry), intermittent (often seasonally dry) and ephemeral (occasionally full) lakes on the tableland tract of the southern Monaro from Bullanamung Lake (Lat. 36° 00' 15"), 28 km north of Cooma, to Green Lake (Lat. 37° 01' 35"), 15 km south of Bombala. These lakes would be classified as Mountain Lakes and Swamps, (a) perennial lakes and (c) ephemeral

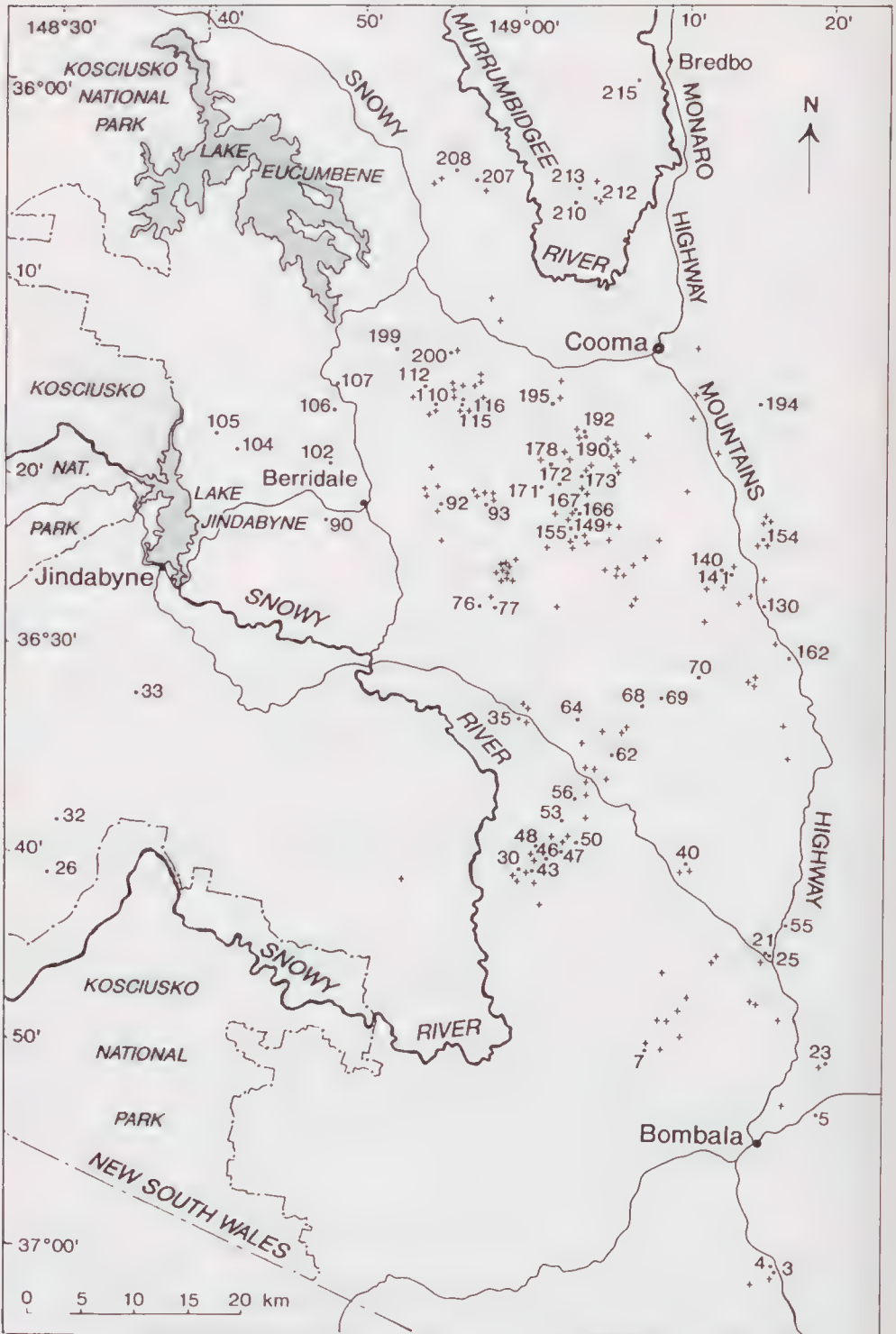


Figure 1. Distribution of the 215 lakes on the southern Monaro; the 65 lakes sampled during this survey are numbered (see also Appendix 1).

lakes/swamps, in the classification suggested by Jacobs and Brock (1993). The region is bounded in the east by the South Coast and Kybean Ranges and in the west by the steep eastern escarpment of Kosciusko National Park (Figure 1). Glacial lakes and swamps in the alpine tract of the Monaro (Kosciusko National Park), or wetlands formed by depositional processes such as backswamps, were not included in the survey.

Most of the lakes are between 800 and 1100 m altitude. The lowest elevation of 760 m (lakes 1–3 Figure 1, including Green Lake) was recorded south of Bombala and the highest elevation of 1220 m on the Monaro Range near Middlingbank north of Berridale (lake 199, Figure 1). Rainfall ranges from 450 to 700 mm per annum with falls mainly in the winter (Costin 1954). Temperatures are cold in winter and mild in summer.

The land-use history of the region is summarised in Benson (1994). Most lakes are on private land that has been grazed by sheep and/or cattle for over 100 years. The intensity of grazing has probably varied from property to property. Little is documented about the extent of lake bed cropping in the region, but discussions with landholders indicate that it has been limited compared to the level of cropping on the lake beds of inland New South Wales.

Geomorphology

The Monaro lakes fall within the 'lentic tablelands' wetland geomorphological definition of Pressey and Harris (1988). Of the 215 lakes on the Monaro, the majority (185, or 86%) are on Eocene basalt; 17 (8%) are on granitic rock types; 4 (2%) are on sedimentary or metamorphic rocks; and 9 (4%) are at the junction of basalt and granitic rocks (Appendix 1). The lake beds are composed of varying depths of dark-grey cracking clays often incorporating carbonate nodules (Pillans 1987).

The most likely explanation for the formation of the Monaro lakes is the process of deflation during the last ice age (Pillans 1987). Lakes on basalt terrain in the midlands of Tasmania are also considered to have formed by deflation (Kirkpatrick & Tyler 1988). Similarly formed lakes are those on the undulating pampa in Argentina and Uruguay in South America (Soriana 1992). Since deflation lakes tend to occur in landscapes dominated by grassland vegetation, the climatic and soil property requirements for the maintenance of grassland — low precipitation, periodic droughts and heavy textured soils (Benson 1994) — are also important for maintenance of the lakes. Such a climate leads to frequent drying out of the lakes, and accumulated sediments on the lake beds are blown away in dry times. Most of the Monaro lakes have aeolian sediment 'shadows' spreading from their eastern shores. These are composed of clay pellets formed during lake-bed surface drying (Pillans 1987). Lake lunettes are rare.

The largest and deepest lakes in the study area dry out only during prolonged drought. Some of these are situated at the junction of basalt flows and granite (examples include Maffra, Boundary, Buckleys and Cootralantra Lakes). Their origin may not be solely due to deflation. During volcanic activity in the Eocene, basalt flows may have dammed valleys and formed depressions in the landscape. These could subsequently have developed into lakes (G. Taylor pers. comm.).

Methods

Data collection

Lakes and wetland depressions greater than one hectare are shown on the 1:25 000 scale topographic maps covering the region (Land Information Centre, Department of Conservation and Land Management 1971–1988). We numbered the lakes from south to north (Figure 1), and their size, altitude and substrate (Australian Geological Survey 1964) were documented (Appendix 1). Artificial dams or impounded lakes were excluded from the survey.

Major environmental variables likely to influence the floristic composition of the lakes included size of lake, degree of permanence, altitude, geography and substrate. Approximately 70% of the large lakes (> 10 ha) and 16% of the more numerous small lakes (< 3 ha) were surveyed (Figure 2).

Sampling took place in February 1993 after a wetter than normal spring and summer (Bob Wilkinson pers. comm.) when the lakes were near-full. Some ephemeral lakes had already dried. This timing ensured that most aquatic species were flowering or fruiting.

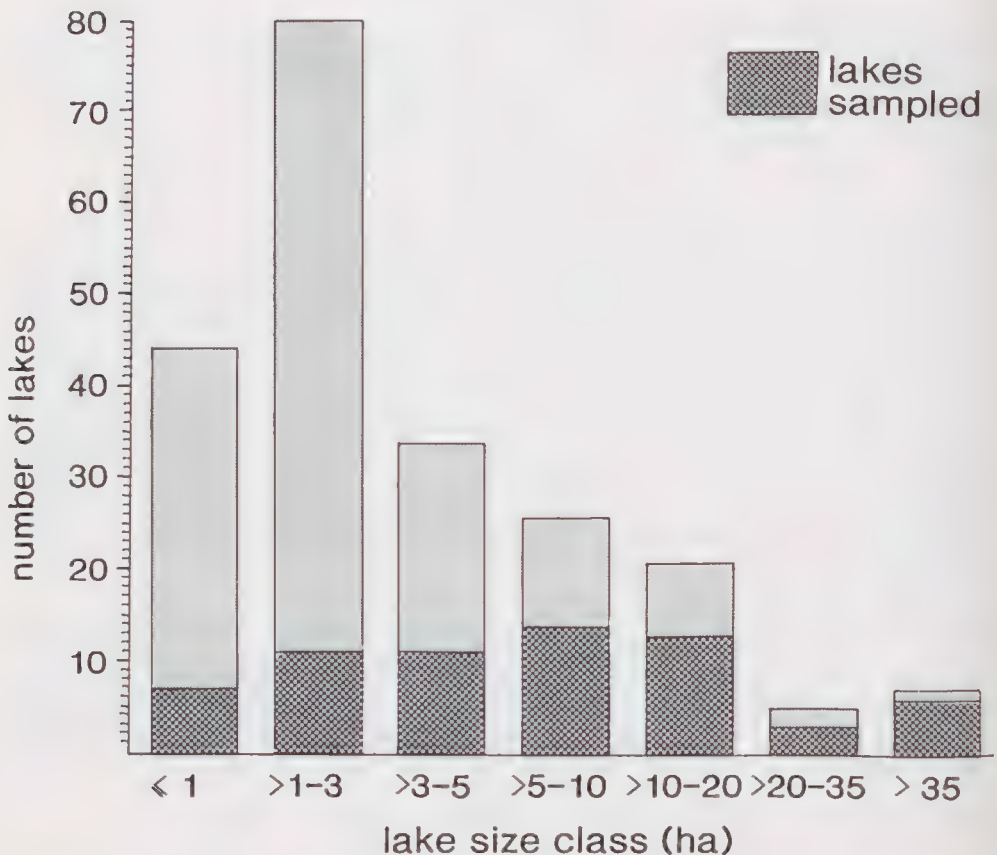


Figure 2. Numbers of lakes in size classes showing the proportion of each class sampled.

At each lake all species were recorded and assigned a cover rating on a six-point scale; 0–1, 2–5, 6–25, 26–50, 50–75, 76–100%. Species were recorded from both the water and the adjoining strandline, which varies in position and width as water levels rise and fall. Each wetland was treated as a single site — all plants on the strandline (regularly inundated section of the shoreline) and growing in the water were combined and treated together. Lakes were circumnavigated or traversed by foot. In deeper lakes several sorties were made from the shore and, in the largest, a small boat was used. Any sign or suggestion of vegetation in water was checked and identified. Standard-sized quadrats were not used and, sample size varied substantially, but this was not seen as a confounding factor because of the ease of dispersal of waterplants within water bodies. The lakes were sampled only once. Given the ephemeral nature of some of these lakes and the life cycle of many waterplants, the abundance and presence of some species would vary over time. We are confident, however, that most waterplant species from the lakes would persist and be recorded in future surveys.

Data analysis

The sample sites and species were classified into floristic groups using an agglomerative hierarchical classification with the Kulczynski coefficient dissimilarity measure, and applying the flexible unweighted paired group arithmetic averaging (UPGMA) sorting strategy of PATN (Belbin 1993). The benefits of using the Kulczynski coefficient compared to other measures are discussed in Faith, Minchin and Belbin (1987). They found it was most robust to variations in assumed models of species response. The analysis incorporated the species cover rating data in a matrix of 65 sites by 110 species. Exotic species were included.

Selection of three floristic groups (Communities 2, 3 and 4) was made at the 0.85 dissimilarity measure. One group (Community 1) was selected at the 0.78 measure.

A two-way table was generated using the 2-step association measure on species and Kulczynski coefficient on sites (Belbin 1993). This aided in identifying common and indicator plant species in each UPGMA-selected floristic group. The mean plant species richness for the lakes selected into each floristic group (plant community) was calculated. The mean size of the lakes classified into the floristic groups was also calculated.

Hybrid non-metric multidimensional scaling (NMDS) using PATN (Belbin 1993) was used to ordinate the lake floristic data along three vectors. To test the nature of the environmental space being described by these vectors, simple relationships of the selected floristic groups (1–4) with the environmental attributes substrate, altitude and size of lake were investigated. Means and medians of altitude, lake size and geology were derived using the GSTA (group statistics) module of PATN.

Results

The numbered lakes shown on Figure 1 are those sampled in this survey. Figure 2 summarises the number of lakes in several size classes and the proportion of each class sampled. The classification of the sampled lakes into floristic communities is presented in Figure 3. Community classification is based on Kirkpatrick and Tyler (1988).

Table 1. Percentage frequency of plant species recorded in each wetland plant community and for all sites

Community 1 = shallow freshwater herb-sedge marsh, low elevations

Community 2 = shallow freshwater herb-herb marsh, high elevations

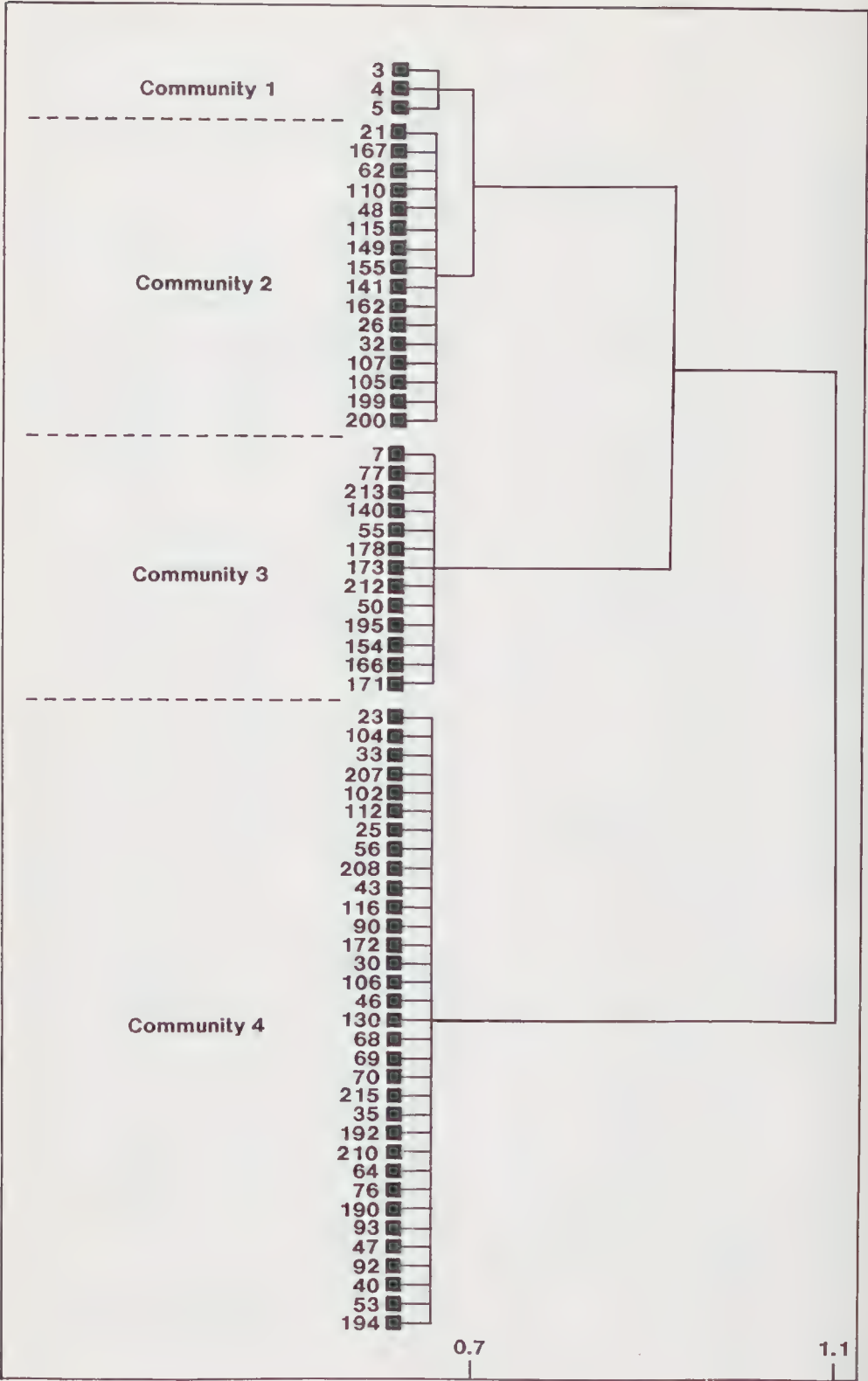
Community 3 = shallow ephemeral freshwater herb-grass marsh

Community 4 = deep freshwater sedge-herb marsh

* = exotic species

Species	Community (%)				
	1	2	3	4	All
<i>Agrostis avenacea</i> var. <i>avenacea</i> (Poaceae)	100	87	100	91	92
<i>Alisma plantago-aquatica</i> (Alismataceae)	0	6	0	0	1
<i>Amphibromus nervosus</i> (Poaceae)	67	100	39	12	42
<i>Asperula conferta</i> (Rubiaceae)	0	6	0	0	1
<i>Australopyrum retrofractum</i> (Poaceae)	0	6	0	0	1
<i>Azolla filiculoides</i> var. <i>rubra</i> (Azollaceae)	0	12	0	3	5
* <i>Batrachium trichophyllum</i> (Ranunculaceae)	33	0	0	3	3
<i>Bolboschoenus caldwellii</i> (Cyperaceae)	0	0	0	9	5
<i>Brachycome radicans</i> (Asteraceae)	33	25	8	3	11
* <i>Callitriche stagnalis</i> (Callitrichaceae)	0	0	0	3	1
<i>Cardamine tenuifolia</i> (Brassicaceae)	0	0	8	3	3
<i>Carex bichenoviana</i> (Cyperaceae)	0	19	15	79	48
<i>Carex gaudichaudiana</i> (Cyperaceae)	0	12	0	0	3
<i>Carex inversa</i> (Cyperaceae)	0	0	0	6	3
<i>Carex tereticaulis</i> (Cyperaceae)	33	25	8	33	26
* <i>Centaurium erythraea</i> (Gentianaceae)	0	0	0	6	3
<i>Centipeda cunninghamii</i> (Asteraceae)	66	44	69	15	35
<i>Chenopodium glaucum</i> (Chenopodiaceae)	0	0	8	30	17
<i>Chenopodium pumilio</i> (Chenopodiaceae)	0	6	8	0	3
* <i>Cirsium vulgare</i> (Asteraceae)	0	0	15	6	6
<i>Crassula helmsii</i> (Crassulaceae)	66	44	23	85	62
<i>Cyperus lhotskyanus</i> (Cyperaceae)	0	6	0	6	5
<i>Deyeuxia quadriseta</i> (Poaceae)	0	12	0	0	3
<i>Dichondra repens</i> (Convolvulaceae)	0	0	0	3	1
<i>Elatine gratioloides</i> (Elatinaceae)	33	6	15	0	6
<i>Eleocharis acuta</i> (Cyperaceae)	100	100	69	73	78
<i>Eleocharis atricha</i> (Cyperaceae)	0	0	0	9	5
<i>Eleocharis gracilis</i> (Cyperaceae)	0	0	0	6	3
<i>Eleocharis pusilla</i> (Cyperaceae)	33	62	31	39	43
<i>Eleocharis sphacelata</i> (Cyperaceae)	100	0	0	0	5
<i>Epilobium billardierianum</i>					
subsp. <i>cinereum</i> (Onagraceae)	33	0	0	3	3
* <i>Festuca elatior</i> (Poaceae)	0	0	0	3	1
<i>Glossostigma elatinoides</i> (Scrophulariaceae)	66	87	30	21	41
<i>Glyceria australis</i> (Poaceae)	33	0	0	0	1
<i>Gnaphalium sphaericum</i> (Asteraceae)	100	31	0	21	23
<i>Helichrysum scorpioides</i> (Asteraceae)	33	0	0	0	1
<i>Hemarthria uncinata</i>					
var. <i>uncinata</i> (Poaceae)	33	19	0	9	11
* <i>Holcus lanatus</i> (Poaceae)	33	0	8	12	9
* <i>Hordeum marinum</i> (Poaceae)	0	12	8	52	31
<i>Hydrocotyle algida</i> (Apiaceae)	0	0	0	3	1
<i>Hydrocotyle peduncularis</i> (Apiaceae)	100	88	8	30	43
<i>Hypericum gramineum</i> (Clusiaceae)	33	0	0	0	1
* <i>Hypochaeris radicata</i> (Asteraceae)	0	0	8	3	3
Blue green algae	0	0	8	0	1
<i>Chara</i> sp.	66	37	15	67	49
Green algae	0	6	8	39	23
<i>Isolepis fluitans</i> (Cyperaceae)	66	0	8	0	5
<i>Isolepis platycarpa</i> (Cyperaceae)	33	31	69	27	37
<i>Isolepis subtilissima</i> (Cyperaceae)	33	0	0	0	1
<i>Juncus articulatus</i> (Juncaceae)	100	56	8	42	42

<i>Juncus australis</i> (Juncaceae)	66	50	0	30	31
* <i>Juncus bufonius</i> (Juncaceae)	0	12	15	24	18
<i>Juncus holoschoenus</i> (Juncaceae)	33	19	0	0	6
<i>Juncus</i> sp. (Juncaceae)	66	37	0	12	18
<i>Juncus subsecundus</i> (Juncaceae)	66	12	15	18	18
<i>Juncus usitatus</i> (Juncaceae)	33	19	0	0	6
<i>Juncus vaginatus</i> (Juncaceae)	33	25	0	36	26
<i>Lemna disperma</i> (Lemnaceae)	33	6	0	9	8
<i>Lepilaena bilocularis</i> (Zannichelliaceae)	0	0	0	64	32
<i>Lilaeopsis polyantha</i> (Apiaceae)	66	12	0	6	9
<i>Limosella australis</i> (Schrophulariaceae)	33	37	62	88	68
<i>Lythrum hyssopifolia</i> (Lythraceae)	33	0	0	0	1
<i>Marsilea angustifolia</i> (Marsileaceae)	0	50	38	3	22
<i>Marsilea drummondii</i> (Marsileaceae)	33	12	15	6	11
<i>Mentha diemenica</i> (Lamiaceae)	0	12	0	3	5
<i>Myriophyllum caput-medusae</i> (Haloragaceae)	0	37	0	6	12
<i>Myriophyllum simulans</i> (Haloragaceae)	100	100	8	3	32
<i>Myriophyllum verrucosum</i> (Haloragaceae)	0	6	8	30	18
<i>Neopaxia australasica</i> (Portulacaceae)	0	31	0	0	8
<i>Nymphoides montana</i> (Menyanthaceae)	66	0	0	0	3
<i>Ottelia ovalifolia</i> (Hydrocharitaceae)	0	19	0	0	5
<i>Paspalum distichum</i> (Poaceae)	0	0	8	3	3
<i>Persicaria decipiens</i> (Polygonaceae)	0	0	0	3	1
<i>Persicaria maculosa</i> (Polygonaceae)	0	19	31	6	14
<i>Persicaria prostrata</i> (Polygonaceae)	33	44	54	36	42
* <i>Phalaris aquatica</i> (Poaceae)	0	6	0	0	1
* <i>Polypogon monspeliensis</i> (Poaceae)	0	0	0	18	9
<i>Potamogeton crispus</i> (Potamogetonaceae)	33	19	8	6	11
<i>Potamogeton ochreatus</i> (Potamogetonaceae)	66	37	31	36	37
<i>Potamogeton tricarinatus</i> (Potamogetonaceae)	100	100	46	15	46
* <i>Potentilla anserina</i>					
subsp. <i>anserina</i> (Rosaceae)	0	6	0	9	6
<i>Pratia surrepens</i> (Lobeliaceae)	100	25	0	0	11
<i>Psoralea tenax</i> (Fabaceae)	0	0	0	6	3
<i>Puccinellia stricta</i> (Poaceae)	0	0	31	30	22
<i>Ranunculus inundatus</i> (Ranunculaceae)	100	94	15	3	32
<i>Ranunculus sceleratus</i> (Ranunculaceae)	0	6	0	9	6
<i>Ranunculus diminutus</i> (Ranunculaceae)	0	37	15	97	62
<i>Rorippa palustris</i> (Brassicaceae)	0	0	8	3	3
<i>Rumex brownii</i> (Polygonaceae)	0	12	0	6	6
* <i>Rumex crispus</i> (Polygonaceae)	33	37	23	52	42
<i>Rumex tenax</i> (Polygonaceae)	33	6	0	0	3
<i>Ruppia megacarpa</i> (Potamogetonaceae)	0	0	0	3	1
<i>Ruppia polycarpa</i> (Potamogetonaceae)	0	0	0	3	1
* <i>Salix alba</i> (Salicaceae)	33	0	0	3	3
<i>Schoenoplectus pungens</i> (Cyperaceae)	0	0	0	24	12
<i>Schoenus apogon</i> (Cyperaceae)	33	6	0	12	9
<i>Schoenus nitens</i> (Cyperaceae)	0	0	0	3	1
<i>Stellaria angustifolia</i> (Caryophyllaceae)	0	31	8	6	12
* <i>Trifolium campestre</i> (Fabaceae)	0	6	0	0	1
* <i>Trifolium dubium</i> (Fabaceae)	0	0	15	15	11
* <i>Trifolium fragiferum</i> (Fabaceae)	0	0	0	3	1
* <i>Trifolium glomeratum</i> (Fabaceae)	0	0	15	3	5
* <i>Trifolium repens</i> (Fabaceae)	0	19	23	18	19
<i>Utricularia monanthos</i> (Lentibulariaceae)	33	0	0	0	1
<i>Vallisneria gigantea</i> (Hydrocharitaceae)	66	0	0	0	3
* <i>Veronica anagallis-aquatica</i> (Scrophulariaceae)	0	25	8	21	18
<i>Villarsia exaltata</i> (Menyanthaceae)	33	0	0	0	1
<i>Viola hederacea</i> (Violaceae)	0	0	8	0	1
* <i>Vulpia myuros</i> (Poaceae)	0	0	0	3	1
<i>Wolffia australiana</i> (Lemnaceae)	33	6	0	3	5



Floristics

A total of 110 species was recorded during the survey, of which 21 (19%) species were exotic (Table 1). Nomenclature follows Harden (1990–93).

The most commonly recorded native species were *Agrostis avenacea* (in 92% of sites), *Eleocharis acuta* (78%), *Limosella australis* (68%), *Crassula helmsii* (62%), *Ranunculus diminutus* (62%), *Carex bichenoviana* (48%), *Potamogeton tricarinatus* (46%), *Amphibromus nervosus* (42%), *Juncus articulatus* (42%) and *Hydrocotyle peduncularis* (43%).

The most common exotic species were *Rumex crispus* (42%), *Hordeum marinum* (31%), *Trifolium repens* (18%) and *Veronica anagallis-aquatica* (18%).

Native species recorded only once during the survey include *Ruppia megacarpa*, *R. polycarpa*, *Villarsia exaltata*, *Lythrum hyssopifolia*, *Isolepis subtilissima*, *Alisma plantago-aquatica* and *Australopyrum retrofractum*.

Cardamine tenuifolia was recorded for the first time in New South Wales and other native species including *Ruppia polycarpa*, *Myriophyllum simulans*, *Marsilea angustifolia* and an undescribed form of *Marsilea drummondii* were recorded for the first time on the Southern Tablelands. The exotic forb *Potentilla anserina* subsp. *anserina* was also recorded for the first time on the Southern Tablelands.

The submerged aquatic *Lepilaena bilocularis* and strandline sedge *Carex bichenoviana*, were found to be more common in the region than previously indicated from herbarium records.

Wetland plant communities

The structure and species composition of the four wetland communities are described below. Dominant species are commonly recorded species with high cover ratings that may be found in more than one community. Indicator species are plants that are largely confined to one type of community.

Community 1. Shallow freshwater herb-sedge marsh: *Myriophyllum simulans*–*Eleocharis sphacelata*–*Nymphoides montana*–*Pratia surrepens*

Structure: Tall emergent sedge layer over part of the lake. A large proportion of the surface of the lake is covered with floating-attached or emergent waterplants and there is usually a dense mat of forbs covering the strandline. (Figure 4.)

No. samples: 3

Mean lake size: 5 ± 1.5 ha.

Mean no. native sp.: 28 ± 4

Mean no. exotic sp.: 2 ± 1

Dominant species: *Myriophyllum simulans*, *Potamogeton tricarinatus*, *Eleocharis sphacelata*, *Nymphoides montana*, *Pratia surrepens*, *Hydrocotyle peduncularis*, *Eleocharis acuta*, *Agrostis avenacea*.

Indicator species: *Eleocharis sphacelata*, *Nymphoides montana*, *Pratia surrepens*, *Hydrocotyle peduncularis*, *Isolepis fluitans*, *Glyceria australis*, *Valisneria gigantea* and *Utricularia monanthos*.

Substrate and distribution: Found in lakes on granitic and basalt substrates at lower altitudes (760–830 m) in the Bombala district. This area receives a higher rainfall than the rest of the study area.

Figure 3 (left). Agglomerative classification of lakes (see Appendix 1 for lake numbers) by their similarity of plant composition selected at the 0.78 disassociation value. This analysis is based on cover ratings for both native and exotic species.

Comment: Community 1 is restricted to small lakes (< 5 ha) in the far south-eastern section of the study area at relatively lower altitudes (a median at 760 m). It contains a high number of native

species. Many of the species in Community 1 are also found in Community 2, but, within the study area, several species, such as the floating-attached *Nymphoides montana*, are confined to it.

Community 2. Shallow freshwater sedge-herb marsh: *Myriophyllum simulans*–*Potamogeton tricarinatus*–*Eleocharis acuta*–*Glossostigma elatinoides*–*Amphibromus nervosus*

Structure: Short sedge layer over-topping a dense forb ground cover on strandline. Extensive emergent and floating-attached waterplants present on the surface of the lakes. (Figure 5.)

No. samples: 16

Mean lake size: 3 ± 2 ha.

Mean no. native sp.: 20 ± 5

Mean no. exotic sp.: 1 ± 0.9

Dominant species: *Myriophyllum simulans*, *Potamogeton tricarinatus*, *Eleocharis acuta*, *Glossostigma elatinoides*, *Amphibromus nervosus*, *Agrostis avenacea*, *Eleocharis pusilla*.

Indicator species: *Myriophyllum caput-medusae*, *Stellaria angustifolia*, *Neopaxia australasica*, *Ottelia ovalifolia*, *Carex gaudichaudiana*.

Substrate and distribution: Found in deflation lakes on basalt south of Cooma with a sub-group (lakes 26, 32, 107, 105, 199, and 200) in deflation lakes on granite near Berridale and Jindabyne. This community occurs at higher altitudes than the others in the study area, ranging from 880 m to 1220 m.

Comment: Community 2 is mainly recorded from small to medium, intermittent lakes (median 2 ha) at high altitudes (median 1030 m). These lakes contain a high native species richness with an abundance of the floating-attached waterplant *Potamogeton tricarinatus* and the submerged or emergent *Myriophyllum simulans*. Few exotic species were recorded from this community.



Figure 4. The flora in Weddenjery Lake south of Bombala is grouped into Community 1 and contains several species not recorded in the other communities, including the floating-attached *Nymphoides montana* in the foreground.



Figure 5. Boundary Lake at Bungarby shown here, and other lakes grouped under plant Community 2, contain abundant emergent, submerged and floating-attached waterplants. They are usually shallow and intermittently dry.



Figure 6. Plant community 3 is often confined to small ephemeral lakes. These contain low numbers of native species, often dominated by *Agrostis avenacea*, and heavily grazed by stock.

Community 3. Shallow ephemeral freshwater herb-grass marsh: *Agrostis avenacea*–*Centipeda cunninghamii*–*Eleocharis acuta*–*Crassula helmsii*–*Isolepis platycarpa*

Structure: Mid-tall grass layer over sparse ground cover of forbs.

Indicator species: *Isolepis platycarpa*, *Centipeda cunninghamii*.

No. samples: 13

Mean lake size: 5 ± 4 ha

Mean no. native sp.: 11 ± 4

Mean no. exotic sp.: 1 ± 2

Dominant species: *Agrostis avenacea*, *Centipeda cunninghamii*, *Eleocharis acuta*, *Crassula helmsii*, *Isolepis platycarpa*, *Limosella australis*, *Persicaria prostrata*.

Substrate and distribution: Mainly growing on small ephemeral deflation lakes on basalt, ranging in altitude from 740 m to 1080 m. Distributed throughout the study area except for the far western section. (Figure 6.)

Comment: Compared to the other communities, lakes grouped under Community 3 contain an impoverished native flora and a high proportion of exotic plants on the strandline, which is often dominated by the native grass *Agrostis avenacea*. They also were recorded from small to medium sized lakes (median 5 ha) and high altitudes (median 990 m).

Community 4. Deep freshwater sedge-herb marsh: *Carex bichenoviana*–*Ranunculus diminutus*–*Lepilaena bilocularis*

Structure: Open sedgeland over a low forbland on the strandline. Submerged waterplants more

common than emergent plants in the lakes. Floating-attached waterplants absent. (Figure 7.)



Figure 7. The 36 ha Black Lake is grouped into plant Community 4, which is mainly confined to large perennial lakes, lacks emergent or floating-attached plants, and contains submerged species rare in the other plant communities.

No. samples: 33

Mean lake size: 28 ± 42 ha

Mean no. native sp.: 16 ± 5

Mean no. exotic sp.: 2 ± 1

Dominant species: *Carex bichenoviana*–*Crassula helmsii*–*Limosella australis*–*Ranunculus diminitus*–*Lepilaena bilocularis*.

Indicator species: *Lepilaena bilocularis*, *Carex bichenoviana*, *Schoenoplectus pungens*, *Myriophyllum verrucosum*.

Substrate and distribution: Predominantly in large deflation or palaeo-lava-blocked lakes

distributed throughout the study area on both basalt and granite. Altitude range 750 m to 1160 m. The most conspicuous aspect of the flora in the lakes classified under Community 4 is that they lack floating-attached waterplants and the emergent/submerged *Myriophyllum simulans*, whereas the submerged *Lepilaena bilocularis* is often abundant.

Comment: Lakes grouped under Community 4 contain, on average, lower numbers of native species than lakes grouped under Communities 1 and 2 but greater numbers than lakes grouped under Community 3. Most of the lakes grouped under Community 4 are large (> 10 ha, median 16 ha) but there is a large deviation around the mean of 28 ha.

Environmental determinants

The mean lake size of sites classified into Community 4 are larger than the sites classified under the other three communities. There was, however, no significant correlation at $p < 0.001$ for this conclusion in the GSTA analysis, although a large deviation was derived for lake sizes in Community 4 compared to the other communities. A few small lakes were classified into Community 4 and apparently this limited the degree of significance of the correlation.

The GSTA analysis also found no significant correlation between the distribution of the four communities to either geology or altitude. As mentioned above, several species are restricted to Community 1 at lower altitudes but this fact was not enough to cause the GSTA analysis to significantly correlate Community 1 to a vector that may reflect altitude.

Discussion

The distributions of wetland plants in the lakes on the Monaro are sufficiently varied to allow for the delimitation of four plant communities. These communities, however, share many widely distributed, commonly occurring species, for example *Eleocharis acuta* and *Glossostigma elatinoides*. Such species indicate that the sites shared sufficient characteristics to justify being analysed together. The whole study area was within the geographic distribution of most of the wetland species recorded. There were a number of species with very restricted distributions in the study area (although they are commonly found elsewhere), for example *Ruppia megacarpa*, *R. polycarpa* and *Villarsia exaltata*. The presence of such species indicated that there could be some benefit from widening the study area in further studies so that wider geographical comparisons of wetland communities can be made.

The data suggest that Community 4 is most distinct from the other communities and there is a trend for this community to be confined to large lakes whereas small lakes could fall into any of the communities.

The distribution of communities 1, 2 and 4 on the Monaro does not appear to be influenced by substrate, since these communities are present in lakes on all the three geological types found in the study area. Higher temperatures and higher rainfall

may explain why Community 1 is restricted to the south-eastern edge of the study area. This community shows some similarity in its floristic composition to the wetlands on basalt in the Guyra District of the Northern Tablelands of NSW. Species such as *Nymphoides montana*, *Glyceria australis* and *Eleocharis sphacelata* grow on the Northern Tablelands (Harden 1990, 1993) and elsewhere but are restricted to Community 1 on the Monaro.

Community 2, which is mainly composed of lakes with high numbers of native species, seems to be composed of small to medium-sized lakes that are shallow but not ephemeral. We expect that these lakes would dry out regularly but would probably fill each winter and stay full for much of the year. In contrast, most of the lakes classified under Community 3 appear to be very shallow and ephemeral. They are probably dry for most of the year and are often dominated by the grass *Agrostis avenacea*. Perhaps many of the plants recorded in the lakes classified under Community 2 cannot survive the drier conditions of the lakes classified under Community 3.

There is a correlation between lake size (and probably depth) and the presence or absence of certain floating-attached and emergent species. The large lakes in Community 4 may lack floating-attached waterplants because they contain stretches of water that are of sufficient length to allow large waves to develop. This wave action may damage plants at the surface and could lead to increased turbidity that would inhibit plant establishment in all but the shallowest sections of a lake. These shallower sections are quickly expanded as water levels drop and are subject to the most extreme wave action. The smaller lakes tend to be shallower than the large lakes and may be less turbid if wave action is minor, therefore a large proportion of the lake-bottom would receive sufficient light for plant growth — encouraging the growth of a greater number of floating-attached and emergent waterplants. *Lepilaena* and other submerged species may survive wave action in these large lakes because they have submerged pollination mechanisms — they can complete their life cycles under water.

Salinity levels in the lakes probably vary over time and between the lakes, though there are few data. As well as possible long-term cycles in salinity levels there may be short-term fluctuations associated with filling and evaporation. Based on our floristic data it appears that some lakes contain a greater proportion of salt-tolerant species than others. The more permanent lakes (which most often are the largest lakes) contain a higher number of salt tolerant species. The larger lakes in Community 4 do not dry out as often as the smaller lakes that were generally grouped under the other communities, therefore salt may accumulate. For example, the 20 ha Kiah Lake, which is situated north of Berridale, has dried out only four times in the last 60 years (J. Allen pers. comm.). Species such as *Lepilaena bilocularis*, *Myriophyllum verrucosum* and *Carex bichenoviana* may have higher salt tolerance than other species and this could explain their abundance in Community 4 and their rarity in the other communities.

The shape of lakes may also be a factor determining the presence of species. Lakes with gradual slopes and extensive areas of shallows may contain more habitat suitable for the survival of emergent species than those that are steep-sided. Even within the same plant community, variation occurs. Avon Lake (lake 56) and Maffra Lake (lake 35) are grouped into Community 4 on the basis of their shared floristics, yet Avon Lake lacks emergent species and Maffra Lake contains emergent species such as *Schoenoplectus pungens*.

Further research could test some of the hypotheses discussed above about the causes of species distribution in the Monaro lakes (salinity, wave action, lake shape). For example, it may be worth investigating the relationship between salinity, lake size and floristic composition. However, salinity readings that do not record fluctuation within years and between years will not be meaningful.

Conservation, threats and management

At present no wetland on the Monaro is protected either in a conservation reserve or under a conservation management agreement. Most of the wetlands are on private land but some are in travelling stock reserves or are dedicated as water reserves. Some lakes have been cropped or drained. The largest lake on the Monaro, Beards Lake (lake 53), has been drained and is now dry (Figure 8). Most lakes are grazed when water levels are low and pugging of the edges of the lakes by stock may damage the plants.

Although we have no documentation on the pre-European composition of the lakes, many contain a high number of species. This indicates that management of some properties (or sections of them) is compatible with maintaining a range of wetland plant species. Lightly grazed properties, such as 'Quartz Hill' south of Cooma, contain several wetlands grouped under Community 2 that were recorded as being untrampled and rich in species. 'Quartz Hill' relies on native rather than improved pastures and uses less fertilizer than many other properties. We suggest that preventing over-stocking in lake catchments is a key way of limiting the flow of sediments and nutrients into the lakes.

As the majority of lakes are on private land a program aimed at educating landholders about their flora and fauna may be an effective means of ensuring that at least some wetlands are managed sympathetically. Conservation agreements between landholders and a suitable government agency would be a more secure way of protecting a select range of lakes. Such agreements should deal with matters such as limiting cropping on the lake beds, controlling stock access to lakes during periods when the lakes are vulnerable to trampling, and policing illegal game shooting.



Figure 8. A cut channel through a hill on the western side of Beards Lake has drained the largest lake on the Monaro.

As we did not survey every lake in the study area, selection of lakes for conservation may not have covered all lakes of significance. Based on our data, a number of lakes worthy of protection are listed below. These lakes have been selected because they have a high species richness, contain significant species, are representative of a plant community, or contain few weeds and are not heavily trampled by stock.

- Lake 4: Weddenjury Lake (Figure 4), south of Bombala contains 29 species of native waterplants including several species restricted to this section of the study area (Community 1).
- Lake 149: This lake adjacent to the Cooma–Dalgety Road contains 30 native plant species and lacks signs of trampling at its edge (Community 2).
- Lake 105: Eucumbene Road north east of Jindabyne. 24 native species including *Ottelia ovalifolia*. Lightly grazed (Community 2).
- Lake 35 Maffra Lake: The greater portion of this lake is in a fenced-off travelling stock reserve. This area therefore provides an opportunity for a nature reserve to be dedicated with no cost for land acquisition. This lake contains large stands of the tall sedge *Bolboschoenus caldwellii* which was rarely recorded during the survey (Community 4).
- Lake 30: 'Snowleigh' near Bungarby. This lake appeared to be undisturbed by stock and had a relative species-rich flora (Community 4).
- Lake 46: 'Peters Park'. This lake was not pugged by stock and contained a high number of species (28 species) (Community 4).
- Lake 92: Carrolls Lake. This lake was fenced-off from stock and contained a large number of waterbirds (Community 4).

A number of other lakes in Community 2 could be considered for protection as they were recorded as being in a sound condition. All of the lakes in Community 3 contain few species and were heavily pugged by stock. Therefore none are recommended for conservation.

Surveys of other lakes in the study area may lead to further proposals for conservation, although the bulk of the unsampled lakes are small, ephemeral, and heavily disturbed and it is unlikely that these would contain features worthy of protection.

Acknowledgements

The field work was partly funded by a grant from the NSW National Parks and Wildlife Service. We thank Dr Margaret Brock for her comments on the text. Elizabeth Ashby helped with data analysis. The figures were prepared by Marianne Porteners and Elizabeth Ashby. Karen Wilson helped with identifications of Cyperaceae, Joy Everett with Asteraceae and Scrophulariaceae, and other botanists of the National Herbarium of New South Wales assisted with identifications of other species. Special thanks go to the many landholders on the Monaro who allowed us to inspect lakes on their properties.

References

- Adam, P., Wilson, N.C. & Huntley, B. (1988) The phytosociology of coastal saltmarsh vegetation in New South Wales. *Wetlands* 7(2): 35-84.
- Australian Geological Survey (1964) Canberra and Bega 1:250 000 geological maps. (Australian

- Geological Survey, Department of Natural Resources: Canberra).
- Belbin, L. (1993) PATN Patern Analysis Package Version 3.5: Technical Reference. (CSIRO Division of Wildlife and Ecology: Canberra).
- Bell, D.M. (1992) Plant phenology in temporary lagoons. Graduate Diploma in Science Thesis. (University of New England, Armidale).
- Benson, J.S. (1994) The native grasslands of the Monaro region: Southern Tablelands of NSW. *Cunninghamia* 3(3): 609–650.
- Briggs, S.V. (1976) Comparative ecology of four New England wetlands. Master of Natural Resources Thesis. (University of New England, Armidale).
- Brock, M.A. & Britton, D.L. (in press) The role of seed banks in the revegetation of Australian temporary wetlands. Proceedings of the Symposium on Restoration of Temperate Wetlands. Sheffield 1993.
- Costin, A.B. (1954) *A study of the ecosystems of the Monaro Region of New South Wales with special reference to soil erosion*. (Government Printer: Sydney).
- Faith, D.P., Minchin, P.R. & Belbin, L. (1987) Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio* 69: 57–66.
- Harden, G.J. (ed.) (1990–93) *Flora of New South Wales* Volumes 1–4. (New South Wales University Press: Kensington).
- Hope, C.S. & Southern, W. (1983) Organic deposits of the Southern Tablelands region, New South Wales. Unpublished report to NSW National Parks and Wildlife Service, Sydney.
- Jacobs, S.W.L. & Brock, M.A. (1993) Wetlands of Australia: southern (temperate) Australia. Pp 244–304 in Whigham, D.F., Dykijova, D. & Henjy *Wetlands of the world I: Inventory, Ecology and Management*. Handbook of Vegetation Science 15/2. (Kluwer: Dordrecht).
- Kirkpatrick, J.B. & Harwood, C.E. (1983) Plant communities of Tasmanian wetlands. *Australian Journal of Botany* 31: 437–451.
- Kirkpatrick, J.B. & Tyler, P.A. (1988) Tasmanian wetlands and their conservation. Pp 1–16 in McComb, A.J. & Lake, P.S. (eds) *The conservation of Australian wetlands*. (Surrey Beatty & Sons: Sydney).
- Norman, F.I. & Corrick, A.H. (1988) Wetlands in Victoria: a brief review. Pp 17–34 in McComb, A.J. & Lake, P.S. (eds) *The conservation of Australian wetlands*. (Surrey Beatty & Sons: Sydney).
- Pillars, B. (1987) Lake shadows — aeolian clay sheets associated with ephemeral lakes in basalt terrain, southern New South Wales. *Search* 18(6): 313–315.
- Pressey, R.L. & Harris, J.H. (1988) Wetlands of New South Wales. Pp 35–57 in McComb, A.J. & Lake, P.S. (eds) *The conservation of Australian wetlands*. (Surrey Beatty & Sons: Sydney).
- Sorian, A. (1992) Rio de la Plata Grasslands. In Coupland, R.T. (ed.) *Natural grasslands: introductions and western hemisphere. Ecosystems of the world*. (Elsevier: Amsterdam).
- Winbush, D.J. & Costin, A.B. (1979a) Trends in vegetation at Kosciusko. II. Subalpine range transects, 1959–1978. *Australian Journal of Botany* 27: 789–831.
- Winbush, D.J. & Costin, A.B. (1979b) Trends in vegetation at Kosciusko. III. Alpine range transects, 1959–1978. *Australian Journal of Botany* 27: 833–871.

Manuscript received 2 March 1994

Manuscript accepted 31 May 1994

Appendix 1. Name, location, size, permanence, altitude, substrate and plant communities of the Monaro lakes, New South Wales

LP = lake permanence (p = permanent (rarely dry), I = intermittent (seasonally dry), E = ephemeral (occasionally full) assigned to each lake sampled

Sub. = substrate (Tb = Tertiary basalt, G = granitic rocks, S = sedimentary and meta-sedimentary rocks)

NA = not assessed; * = lake sampled

Lake no.	Lake name	Map sheet	Grid reference	Size (ha)	LP	Alt. (m)	Sub.	Plant comm.
1		Craigie 100 000	698500 5898800	2	NA	760	G	NA
2		Craigie 100 000	700500 5899200	2	NA	760	G	NA
3*	Green Lake	Craigie 100 000	701100 5899800	3	I	760	G	1
4*	Weddenjerry Lake	Craigie 100 000	700600 5900600	5	I	760	G	1
5*		Coolumbooka 25 000	705200 5915100	6	I	830	Tb	1
6	High Lake	Coolumbooka 25 000	702000 5916000	3	NA	850	Tb	NA
7*		Bukalong 25 000	689300 5921400	2	E	740	Tb	3
8		Bukalong 25 000	689400 5921600	1	NA	750	Tb	NA
9		Bukalong 25 000	690600 5921300	1	NA	750	Tb	NA
10		Bukalong 25 000	692400 5922700	2	NA	860	Tb	NA
11		Bukalong 25 000	690500 5924200	2.5	NA	870	Tb	NA
12		Bukalong 25 000	691200 5924200	3	NA	860	Tb	NA
13		Bukalong 25 000	692100 5924800	5.5	NA	880	Tb	NA
14		Bukalong 25 000	693000 5926100	3	NA	830	Tb	NA
15		Bukalong 25 000	699400 5925500	3	NA	870	Tb	NA
16		Bukalong 25 000	699200 5925700	2	NA	870	Tb	NA
17		Bukalong 25 000	691000 5928700	2	NA	760	Tb	NA
18		Bukalong 25 000	695700 5929800	1	NA	850	Tb	NA
19		Bukalong 25 000	696000 5930200	6.5	NA	850	Tb	NA
20		Bukalong 25 000	700400 5929600	2	NA	920	Tb	NA
21*		Bukalong 25 000	700700 5930000	4	NA	890	Tb	2
22	Green Lake	Cathcart 25 000	705500 5919500	11	NA	820	Tb	NA
23*	Black Lake	Cathcart 25 000	706100 5919900	36	P	820	Tb	4

Appendix 1. (cont.)

Lake no.	Lake name	Map sheet	Grid reference	Size (ha)	LP	Alt. (m)	Sub.	Plant comm.
24		Cathcart 25 000	701500 5923900	4	NA	820	S	NA
25*		Cathcart 25 000	701300 5930100	3	I	880	Tb	4
26*		Thredbo 50 000	632700 5940100	1	I	1170	G	2
27		Numbla Vale 50 000	666600 5938000	5	NA	800	G	NA
28		Numbla Vale 50 000	677800 5937900	4	NA	920	Tb	NA
29		Numbla Vale 50 000	677500 5938200	5	NA	920	Tb	NA
30*		Numbla Vale 50 000	677800 5938700	16	P	920	Tb/G	4
31		Numbla Vale 50 000	678600 5938500	7	NA	940	Tb	NA
32*		Numbla Vale 50 000	634300 5944500	1	I	1040	G	2
33*	Lake Jillamatong	Numbla Vale 50 000	642000 5956500	37	P	1100	G	4
34		Numbla Vale 50 000	678700 5953300	9	NA	880	Tb	NA
35*	Maffra Lake	Numbla Vale 50 000	678000 5953500	23	P	890	Tb/G	4
36		Numbla Vale 50 000	678500 5954800	4	NA	880	Tb	NA
37		Numbla Vale 50 000	678900 5954600	6	NA	880	Tb	NA
38	Burns Lakes	Wangellic 25 000	692800 5938100	5	NA	930	Tb	NA
39	Burns Lakes	Wangellic 25 000	693800 5938200	2	NA	930	Tb	NA
40*	Burns Lakes	Wangellic 25 000	693500 5938900	26	P	920	Tb	4
41	Barkers Lake	Wangellic 25 000	679700 5935500	3	NA	890	Tb	NA
42		Wangellic 25 000	679200 5937600	4	NA	930	Tb	NA
43*	Island Lake	Wangellic 25 000	679200 5938700	15	I	960	Tb	4
44		Wangellic 25 000	679200 5939600	3.5	NA	940	Tb	NA
45		Wangellic 25 000	679000 5940100	5	NA	950	Tb	NA
46*		Wangellic 25 000	680400 5939900	20	P	930	Tb	4
47*		Wangellic 25 000	681900 5940400	11	I	940	Tb	4
48*	Boundary Line	Wangellic 25 000	679600 5941100	4	I	960	Tb/G	2

Appendix 1. (cont.)

Lake no.	Lake name	Map sheet	Grid reference	Size (ha)	LP	Alt. (m)	Sub.	Plant comm.
49		Wangellic 25 000	681900 5941100	2	NA	970	Tb	NA
50*		Wangellic 25 000	683300 5941200	14	I	960	Tb	3
51		Wangellic 25 000	682300 5941700	3	NA	960	Tb	NA
52	Washpool Lake	Wangellic 25 000	680900 5941700	5	NA	950	Tb	NA
53*	Beards Lake	Wangellic 25 000	681700 5943000	215	E	950	Tb	4
54		Wangellic 25 000	684100 5943500	4	NA	960	Tb	NA
55*		Glen Allen 25 000	702700 5933100	5	I	920	Tb	3
56*	Avon Lake	Teapot & Wangellic 25 000	683100 5945300	117	P	950	Tb	4
57		Teapot 25 000	684100 5945600	3	NA	930	Tb	NA
58	Dukes Lake	Teapot 25 000	684300 5947000	24	NA	960	Tb	NA
59		Teapot 25 000	686200 5947100	6	NA	1000	Tb	NA
60		Teapot 25 000	684600 5948600	21	NA	970	Tb	NA
61		Teapot 25 000	684000 5948800	2	NA	970	Tb	NA
62*		Teapot 25 000	686600 5949400	2	I	990	Tb	2
63		Teapot 25 000	683900 5950500	4	NA	950	Tb	NA
64*		Teapot 25 000	683500 5952900	6	I	920	Tb	4
65		Teapot 25 000	685800 5951700	12	NA	930	Tb	NA
66		Teapot 25 000	687600 5951600	4	NA	960	Tb	NA
67		Teapot 25 000	687900 5951900	3	NA	970	Tb	NA
68*	Boundary Lake	Teapot 25 000	689600 5954000	8	I	990	Tb	4
69*	Coopers Lake	Teapot 25 000	691400 5954700	19	P	980	Tb	4
70*		Teapot 25 000	694900 5956600	1	I	1000	Tb	4
71		Teapot 25 000	700000 5956000	1	NA	1090	Tb	NA
72		Teapot 25 000	699800 5956200	2	NA	1100	Tb	NA
73		Teapot 25 000	700300 5956400	1	NA	1100	Tb	NA

Appendix 1. (cont.)

Lake no.	Lake name	Map sheet	Grid reference	Size (ha)	LP	Alt. (m)	Sub.	Plant comm.
74		Nimmitabel 25 000	702900 5948500	2	NA	1020	Tb	NA
75		Nimmitabel 25 000	702500 5951600	1	NA	1080	Tb	NA
76*	Buckleys Lake	Berridale 50 000	674400 5963900	40	P	980	Tb/G	4
77*		Berridale 50 000	675800 5963800	2	E	960	Tb	3
78		Berridale 50 000	675600 795964900	1	NA	940	Tb	NA
79N		Berridale 50 000	677000 5966900	1	NA	900	Tb	NA
79S		Berridale 50 000	677000 5966800	1	NA	900	Tb	NA
80		Berridale 50 000	676600 5966900	1.5	NA	900	Tb	NA
81		Berridale 50 000	676400 5967100	1	NA	900	Tb	NA
82		Berridale 50 000	676000 5967800	3	NA	900	Tb	NA
83		Berridale 50 000	676400 5967700	1.5	NA	900	Tb	NA
84		Berridale 50 000	676700 5967700	2	NA	900	Tb	NA
85		Berridale 50 000	677200 5967900	3	NA	900	Tb	NA
86		Berridale 50 000	676400 5968100	2	NA	920	Tb	NA
87		Berridale 50 000	676200 5968400	1	NA	940	Tb	NA
88		Berridale 50 000	677800 5968700	3	NA	920	Tb	NA
89		Berridale 50 000	671000 5970500	1	NA	820	Tb	NA
90*	Coolamatong Lake	Berridale 50 000	660100 5972600	41	P	900	S	4
91		Berridale 50 000	670300 5973300	1	NA	840	Tb	NA
92*	Carrolls Lake	Berridale 50 000	670600 5974000	5	I	840	Tb/G	4
93*	Salt Lake	Berridale 50 000	675200 5973700	10	P	900	Tb/G	4
94		Berridale 50 000	675900 5974000	1	NA	900	Tb	NA
95		Berridale 50 000	669500 5975000	1	NA	860	Tb	NA
96		Berridale 50 000	669500 5975200	1	NA	860	Tb	NA
97		Berridale 50 000	670500 5975600	1	NA	860	Tb/G	NA

Appendix 1. (cont.)

Lake no.	Lake name	Map sheet	Grid reference	Size (ha)	LP	Alt. (m)	Sub.	Plant comm.
98		Berridale 50 000	674100 5975100	1	NA	900	Tb/G	NA
99		Berridale 50 000	674400 5975000	1	NA	900	Tb	NA
100		Berridale 50 000	675100 5974800	1	NA	900	Tb	NA
101		Berridale 50 000	675700 5974500	1	NA	900	Tb	NA
102*	Kiah	Berridale 50 000	660300 5977900	20	P	900	S	4
103		Berridale 50 000	670100 5977500	4	NA	860	G	NA
104*	Lake Bullen-balong	Berridale 50 000	651700 5979500	19	P	1140	G	4
105*		Berridale 50 000	649800 5980700	3	I	1160	G	2
106*	Hugundara Lagoon	Berridale 50 000	660900 5983200	6	I	980	G	4
107*		Berridale 50 000	661100 5985400	1	I	1080	G	2
108	Wishing Lake	Berridale	670100 5982700	2	NA	1040	Tb	NA
109		Berridale 50 000	670500 5982900	1	NA	1060	Tb	NA
110*		Berridale 50 000	670500 5983400	2	I	1060	Tb	2
111		Berridale 50 000	668500 5984100	3	NA	1060	Tb	NA
112*	Cootralantra Lake	Berridale 50 000	669700 5985100	95	P	1040	Tb/G	4
113		Berridale 50 000	672800 5982900	1	NA	1040	Tb	NA
114		Berridale 50 000	673600 5982800	1	NA	1020	Tb	NA
115*		Berridale 50 000	673000 5983300	1	I	1040	Tb	2
116*	Killmacoola Lagoon	Berridale 50 000	673000 5983800	24	P	1000	G	4
117		Berridale 50 000	675100 5983800	2	NA	1000	Tb	NA
118		Berridale 50 000	672300 5984100	1	NA	1040	Tb	NA
119N		Berridale 50 000	672100 5984600	0.5	NA	1040	Tb	NA
119S		Berridale 50 000	672200 5984400	1	NA	1040	Tb	NA
120		Berridale 50 000	672200 5985100	2	NA	1040	Tb	NA

Appendix 1. (cont.)

Lake no.	Lake name	Map sheet	Grid reference	Size (ha)	LP	Alt. (m)	Sub.	Plant comm.
121		Berridale 50 000	673200 5985200	11	NA	1040	Tb	NA
122		Berridale 50 000	674300 5985200	2	NA	1040	Tb	NA
123		Berridale 50 000	674700 5985500	3	NA	1040	S	NA
124		Berridale 50 000	674900 5985800	3	NA	1040	S	NA
125		Myalla 25 000	694900 5961800	2	NA	1080	Tb	NA
126		Myalla 25 000	681800 5963800	3	NA	990	Tb	NA
127		Myalla 25 000	688800 5963900	0.5	NA	1040	Tb	NA
128		Myalla 25 000	689100 5964300	4.5	NA	1030	Tb	NA
129		Myalla 25 000	698700 5963300	3	NA	1090	Tb	NA
130*		Myalla 25 000	700600 5964100	6	I	1050	Tb	4
131		Myalla 25 000	695300 596500	1	NA	1100	Tb	NA
132		Myalla 25 000	697200 5965300	1	NA	1020	Tb	NA
133		Myalla 25 000	700000 5964900	1.5	NA	1060	Tb	NA
134		Myalla 25 000	686200 5967300	1.5	NA	1080	Tb	NA
135		Myalla 25 000	686900 5966900	2	NA	1080	Tb	NA
136		Myalla 25 000	687400 5966800	4	NA	1080	Tb	NA
137		Myalla 25 000	687000 5967300	4	NA	1080	Tb	NA
138		Myalla 25 000	688800 5967800	1	NA	1110	Tb	NA
139		Myalla 25 000	690100 5968200	2	NA	1100	Tb	NA
140*		Myalla 25 000	697100 5966900	9	E	1000	Tb	3
141*		Myalla 25 000	698100 5966500	6	I	1020	Tb	2
142		Myalla 25 000	698300 5966700	3	NA	1000	Tb	NA
143		Myalla 25 000	700700 5966100	2.5	NA	1020	Tb	NA
144		Myalla 25 000	683200 5969300	1.5	NA	1040	Tb	NA

Appendix 1. (cont.)

Lake no.	Lake name	Map sheet	Grid reference	Size (ha)	LP	Alt. (m)	Sub.	Plant comm.
145		Myalla 25 000	681600 5970100	2	NA	1030	Tb	NA
146		Myalla 25 000	683300 5970100	3	NA	1040	Tb	NA
147		Myalla 25 000	684600 5970200	12	NA	1020	Tb	NA
148		Myalla 25 000	686700 5970100	7	NA	1040	Tb	NA
149*		Myalla 25 000	683500 5970500	7	I	1020	Tb	2
150		Myalla 25 000	684500 5970600	16	NA	1020	Tb	NA
151		Myalla 25 000	691300 5969900	2	NA	1090	Tb	NA
152		Myalla 25 000	700100 5968400	6	NA	1000	Tb	NA
153		Myalla 25 000	700900 5968500	1	NA	990	Tb	NA
154*		Myalla 25 000	700700 5969200	8	E	1000	Tb	3
155*		Myalla 25 000	683400 5971400	2	I	1020	Tb	2
156		Myalla 25 000	686100 5971400	16	NA	1020	Tb	NA
157		Myalla 25 000	687500 5971300	2	NA	1050	Tb	NA
158		Myalla 25 000	701000 5970900	4.5	NA	1000	Tb	NA
159		Myalla 25 000	701700 5970800	2	NA	980	Tb	NA
160		Myalla 25 000	701400 5971700	3	NA	990	Tb	NA
161		Myalla 25 000	682700 5972300	4.5	NA	1010	Tb	NA
162*	Racecourse Lake	Kydra 25 000	703300 5958400	6	I	1090	Tb	2
163		Kydra 25 000	701900 5959500	1	NA	1090	Tb	NA
164		Jillimatong 25 000	681600 5972500	2	NA	1020	S	NA
165		Jillimatong 25 000	683300 5972700	7	NA	1010	Tb	NA
166*		Jillimatong 25 000	683900 5972700	6	I	1000	Tb	3
167*		Jillimatong 25 000	683500 5973400	1.5	I	1020	Tb	2
168		Jillimatong 25 000	694100 5974300	3	NA	990	Tb	NA

Appendix 1. (cont.)

Lake no.	Lake name	Map sheet	Grid reference	Size (ha)	LP	Alt. (m)	Sub.	Plant comm.
169		Jillimatong 25 000	684600 5974700	2	NA	960	Tb	NA
170		Jillimatong 25 000	684300 5974900	13	NA	960	Tb	NA
171*	Green Lake	Jillimatong 25 000	680400 5975400	3	I	990	Tb	3
172*	Arable Lake	Jillimatong 25 000	682100 5975600	16	P	980	Tb	4
173*		Jillimatong 25 000	684200 5976300	5	I	900	Tb	3
174		Jillimatong 25 000	684500 5976800	6	NA	950	Tb	NA
175		Jillimatong 25 000	685000 5977000	2	NA	940	Tb	NA
176		Jillimatong 25 000	687700 5976700	2	NA	980	Tb	NA
177		Jillimatong 25 000	687600 5976900	2	NA	980	Tb	NA
178*		Jillimatong 25 000	681400 5977400	4	I	1080	Tb	3
179		Jillimatong 25 000	689100 5977700	2	NA	930	Tb	NA
180		Jillimatong 25 000	696800 5977700	1.5	NA	930	Tb	NA
181	Tinkers Lake	Jillimatong 25 000	680600 5978300	0.5	NA	1000	Tb	NA
182		Jillimatong 25 000	683300 5977900	1.5	NA	920	Tb	NA
183		Jillimatong 25 000	682700 5978500	1.5	NA	950	Tb	NA
184		Jillimatong 25 000	686700 5978400	4	NA	920	Tb	NA
185		Jillimatong 25 000	687600 5978600	1.5	NA	920	Tb	NA
186		Jillimatong 25 000	687500 5978900	12	NA	920	Tb	NA
187		Jillimatong 25 000	686600 5979500	3	NA	920	Tb	NA
188		Jillimatong 25 000	690500 5979600	1	NA	920	G	NA
189		Jillimatong 25 000	684100 5979900	6	NA	930	Tb	NA
190*		Jillimatong 25 000	684700 5980100	4	I	940	Tb	4
191		Jillimatong 25 000	683800 5980600	2	NA	950	Tb	NA
192*		Jillimatong 25 000	684400 5980500	15	P	940	Tb	4

Appendix 1. (cont.)

Lake no.	Lake name	Map sheet	Grid reference	Size (ha)	LP	Alt. (m)	Sub.	Plant comm.
193		Jillimatong 25 000	694400 5981300	4	NA	920	Tb	NA
194*	Thurbergal Lake	Jillimatong 25 000	701000 5982400	7	I	870	Tb	4
195*		Jillimatong 25 000	681600 5983100	1	E	900	Tb	3
196		Jillimatong 25 000	682500 5983600	1	NA	920	Tb	NA
197		Jillimatong 25 000	694700 5983400	2	NA	880	Tb	NA
198		Jillimatong 25 000	682200 5985200	2	NA	910	Tb	NA
199*		Eucumbene 50 000	666900 5988600	1	I	1220	G	2
200*		Eucumbene 50 000	671900 5988200	4	P	1000	Tb	2
201		Eucumbene 50 000	672800 5988400	4	NA	1000	Tb	NA
202		Eucumbene 50 000	676800 5991100	7	NA	910	Tb	NA
203		Eucumbene 50 000	676200 5993300	4	NA	980	Tb	NA
204		Eucumbene 50 000	675500 6003300	2	NA	1200	Tb	NA
205		Eucumbene 50 000	670700 6004200	1	NA	1140	Tb	NA
206	Long Lake	Eucumbene 50 000	67130 6004600	15	NA	1140	Tb	NA
207*	Rocky Lake	Eucumbene 50 000	674800 6004400	6	I	1160	Tb	4
208*	O'Neills Lagoon	Eucumbene 50 000	672800 6005400	18	P	1120	Tb	4
209		Cooma 25 000	694300 5987800	3	NA	850	Tb	NA
210*	Muddah Lake	Murrumbucca 25 000	684000 6002100	18	P	1000	Tb	4
211		Murrumbucca 25 000	686200 6002200	1.5	NA	1000	Tb	NA
212*		Murrumbucca 25 000	685800 6002500	2	E	1000	Tb	3
213*		Murrumbucca 25 000	684400 6003400	5	E	1010	Tb	3
214		Murrumbucca 25 000	686000 6003700	1.5	NA	1010	Tb	NA
215*	Bullanamang Lake	Murrumbucca 25 000	690400 6013500	4	I	750	G	4

The natural vegetation of the Sydney 1:100 000 map sheet

Doug Benson and Jocelyn Howell

Benson, Doug & Howell, Jocelyn (National Herbarium of New South Wales, Royal Botanic Gardens Sydney, New South Wales, Australia 2000) 1994. The natural vegetation of the Sydney 1:100 000 map sheet. Cunninghamia 3(4): 677–787. The composition and extent of the present natural vegetation on the Sydney 1:100 000 map sheet 9130 (bounded by latitudes 33° 30' and 34° 00' S and longitudes 151° 00' and 151° 30' E) are mapped and described in terms of structure and characteristic species. Sixteen map units covering 42 plant communities are recognised and related to geology and physiography. The most extensive unit is the well-known Hawkesbury Sandstone vegetation, which has been broadly subdivided into Sydney Sandstone Gully Forest (Map unit 10ag), Sydney Sandstone Ridgetop Woodland (Map unit 10ar) and Coastal Sandstone Heath (Map unit 21g). Along the coast north of Long Reef more clayey soils, developed on the Narrabeen Formation, carry tall open-forest, open-forest and coastal heath vegetation. There are patches of scrub on Pleistocene sand deposits at Bouddi and La Perouse, and remnants of open-forest on Wianamatta Shale further west. A map of the vegetation of Ku-ring-gai Chase National Park and Muogamarra Nature Reserve (1:40 000 scale) showing 21 plant communities is provided on the back of the Sydney map.

Twenty-three major conservation reserves for the Sydney map area are briefly described, with species lists for most. Seventy-eight significant plant species are listed for the area, 41 of which are listed as nationally rare or endangered species (Briggs & Leigh 1988 with current ROTAP datings); others are of regional significance. Species listed are either rare, threatened or of botanical significance in terms of geographic distribution. Regional affinities, historical changes, Aboriginal and European impacts, and conservation of vegetation are discussed.

Introduction

In January 1788 the ships of the First Fleet, sent from England with convicts to found a penal colony in New South Wales, entered Birra Birra, the land of the Aboriginal people. They had sailed into the lower reaches of what we now know as Sydney Harbour. As the colonists proceeded westwards towards Sydney Cove, Captain Watkin Tench of the Marines was amongst those 'enjoying the luxuriant prospect of its shores, covered with trees to the water's edge, among which many of the Indians were frequently seen'. George Worgan, surgeon of the *Sirius*, observed 'Here, a romantic rocky, craggy Precipice over which, a little purling stream makes a Cascade There a soft vivid-green, shady Lawn attracts your Eye.' Having found Botany Bay unsuitable for settlement, the fleet's captain, Captain Arthur Phillip, was now searching for a better site further north, at the inlet named Port Jackson by

Captain Cook in 1770. He found this an ideal harbour for the ships, and noted glowingly that: 'The necks of land that form the different coves, and near the water for some distance, are in general so rocky that it is surprizing such large trees should find sufficient nourishment, but the soil between the rocks is good, and the summits of the rocks, as well as the whole country round us, with few exceptions, are covered with trees' (Tench 1779, Worgan 1778, Phillip 1789).

In no time, trees were cut down, the ground cleared, and huts constructed. 'The abode of silence and tranquillity was now changed to that of noise, clamour, and confusion', observed David Collins, legal officer of the new settlement (Collins 1798).

Using historical and contemporary sources, Benson and Howell (1990a), in *Taken for granted: the bushland of Sydney and its suburbs*, described the original vegetation patterns in the County of Cumberland in terms of eight major vegetation types, and discussed the changes that followed the European-style agricultural and urban development of the area over the next two centuries. Particular emphasis was given to each of the 40 local government areas. The present paper, part of the Sydney Region Vegetation Map Series, describes the current condition and extent of the natural vegetation of the north-eastern half of the County of Cumberland, on the Sydney 1:100 000 map sheet, just over 200 years after the beginning of European settlement. As far as practicable, this work does not repeat *Taken for granted*, and only a small amount of historical material is included. Instead, the emphasis is on describing the present-day vegetation in terms of 16 map units, identifying significant areas and species, and includes floristic lists, brief descriptions and references to the major National Parks.



Figure 1. Sydney is probably one of the few great cities of the world where natural vegetation still survives so close to the heart of the city. Here *Banksia integrifolia* grows on the rocky Harbour foreshore at Balls Head.



Figure 2. Exposures of Hawkesbury Sandstone such as this at North Head form the prominent headlands around Sydney Harbour. These 'craggy precipices' delighted the first settlers until they found that this country was so difficult to farm.

The current work updates and enlarges a previous draft report (Benson 1980a) and provisional map (1980). The Sydney 1:100 000 vegetation map sheet is located inside the back cover. A vegetation map of Ku-ring-gai Chase National Park and Muogamarra Nature Reserve at 1:40 000 scale (originally prepared at 1:25 000 scale) is also provided. This map, taken from the vegetation surveys of Thomas and Benson (1985a,b), has not been readily available before, and provides a detailed picture of an important conservation and recreation area.

Location, physiography and climate

The Sydney 1:100 000 Vegetation Map Sheet (based on the Sydney 1:100 000 Topographic Sheet 9130, AUSLIG, Canberra) is bounded by latitudes, 33° 30' and 34° 00' S, and longitudes, 151° 00' and 151° 30' E. It includes the city of Sydney and suburban areas as far west as Parramatta, and the coastline from the Bouddi Peninsula and Broken Bay in the north to Botany Bay and the Georges River in the south. Natural vegetation is almost all confined to the northern half of the sheet, which includes Ku-ring-gai Chase National Park, Marramarra National Park, Muogamarra Nature Reserve, and parts of Brisbane Water and Bouddi National Parks.

Topographically, the northern half of the Sydney map sheet area is a dissected plateau of Hawkesbury Sandstone, the south-eastern corner of the Hornsby Plateau (Herbert 1983), generally 20–50 m elevation near Sydney and rising to 200 m high around

Glenorie in the north-west corner of the map. The major inlets, Broken Bay, Port Jackson and Georges River/Botany Bay are drowned river valleys. Most of the National Parks and remaining natural vegetation are on this Hawkesbury Sandstone landscape, as its thin sandy soils have made it useless for agriculture in comparison with the more fertile Wianamatta Shale soils of the southern half of the map sheet (Chapman & Murphy 1989). The Wianamatta Shale landscapes are gently undulating, covering the higher ridgelines of the Hornsby Plateau in the settled areas of northern Sydney. South of the harbour they are low-lying and extend from the city of Sydney westward to Parramatta, and from there across the Cumberland Plain to the Hawkesbury River and the foot of the Blue Mountains. Being topographically less rugged and having more fertile soils than those on the Hawkesbury Sandstone, these areas were settled and cultivated early in the nineteenth century. In the twentieth century extensive suburban development has followed.

The Narrabeen Group (Newport and Garie Formation, and Terrigal Formation) underlies the Hawkesbury Sandstone and outcrops north of Sydney along the Warringah Peninsula (now part of Pittwater Council area) and north of Broken Bay (Herbert 1983). This has interbedded laminites, shales and sandstones, and forms higher-nutrient soils than the adjacent Hawkesbury Sandstone landscapes. In contrast, in the Eastern Suburbs between Botany Bay and Bondi, the extensive sand deposits of Holocene and Pleistocene age overlying the Hawkesbury Sandstone have extremely low nutrient status, but the original vegetation here has been almost completely destroyed by suburban development.

A few volcanic outcrops occur in the area as diatremes or dykes. Soils have been mapped and discussed by Walker (1960) and Corbett (1972), and most recently a Soil Landscapes Map at 1:100 000 scale has been produced (Chapman & Murphy 1989). This describes 25 soil landscapes and relates closely to the vegetation map units.

Rainfall is related to elevation and coastal influence and occurs throughout the year, but is heaviest in June. It is highest (above 1400 mm p.a.) along the crest of the upper North Shore (e.g. Pymble 1444 mm p.a.) and on the coast (generally 1200–1400 mm p.a.) (e.g. Sydney — Observatory Hill 1209 mm p.a., Narrabeen 1278 mm p.a.). On the lower-lying country around Botany Bay it is about 1100 mm and decreases westward with increasing distance from the coast (Ashfield–Burwood about 1000 mm, Parramatta about 900 mm p.a.). Similar decreases in rainfall occur on the higher sandstone country further north (e.g. Hornsby about 1200 mm, Glenorie 900 mm p.a.) (Bureau of Meteorology 1979).

Mean monthly maximum temperatures for January are 25.9 °C at Sydney and 28.1 °C at Parramatta, while mean monthly minimum temperatures for July are 7.8 °C at Sydney and 4.6 °C at Parramatta. The lowest (screen) minimum temperatures recorded are 2.1 °C for Sydney, -2.9 °C for Parramatta, and -4.6° °C for Pennant Hills. The lowest terrestrial (i.e. ground level) minimum temperature recorded is -4.4 °C for Sydney (the screen minimum was 3.7 °C at this time). Frosts very rarely occur near the coast, the frost period increasing with distance from the coast and with elevation. The average severe frost period (i.e. screen minimum temperature less than 0 °C), for example, is 85 days at Pennant Hills, 38 days at Parramatta and 46 days at Bankstown.

Average soil temperatures at Sydney, at 25 mm depth, range from 11.3 °C in July to 21.4 °C in February (data from Bureau of Meteorology 1979).

Methods

Areas of vegetation with similar structure (Specht 1970) and floristics (dominant species) were grouped to form the map units on the basis of aerial photopatterns and recognisable geological and landscape characteristics. Aerial photography from the New South Wales Department of Lands (Sydney 1982 1:16 000 colour) was used. Geology was based on geological maps (NSW Dept of Mines 1966, NSW Dept of Mineral Resources 1983). Compilation maps were prepared at 1:25 000 scale and subsequently reduced to 1:100 000 scale with little loss of detail.

Present-day (i.e. 1982) naturally-occurring vegetation is mapped; presumed vegetation formerly covering cleared agricultural and suburban areas is shown in Figure 1 and as an inset on the map sheet. An alphanumeric code is used to distinguish individual plant communities. The numeric code represents the structural form of the plant community and the alphabetic code represents the characteristic species. The codes used are consistent throughout the Sydney Region 1:100 000 Vegetation Map Series, allowing map units to be cross-referenced (Benson 1986a, Keith & Benson 1988, Benson & Keith 1990, Benson 1992a).

There are a number of constraints in reducing the complex pattern of natural vegetation to a map format. The map units recognised are not all of equivalent rank. Some are essentially land-units made up of several groupings of plant species, termed plant communities associated with a particular geological or physiographic type (e.g. map units 4a, 10ag, 10ar), whereas others are more early plant associations (*sensu* Beadle & Costin 1952) (map units 6b, 9o). Generally the term 'plant community' is used for the basic vegetation unit. For ease of reference, map units have also been provided with common names based loosely on habitat and composition.

The vegetation map is a diagrammatic attempt to simplify, over an extensive region, the distributional patterns of an often rich and varied flora. It is scale-dependent and map units will almost invariably include unmapped areas of other map units too small to be shown separately. Similarly, most plant communities do not have clear-cut boundaries, but grade into each other, often over a broad ecotone. For mapping purposes such boundaries have to be approximated to a line.

Field checking has been carried out intermittently between 1975 and 1990 and has included recording notes on structure, characteristic species of major strata and associated environmental factors. As major patterns necessary for mapping purposes are generally well known, broadscale computer analyses of floristic data have not been necessary. Floristic analyses of a number of local areas have been carried out and are referred to in the descriptions e.g. coastal vegetation (Adam, Stricker et al. 1989), Ku-ring-gai Chase National Park (Outhred et al. 1985), Lane Cove River National Park (Clarke & Benson 1987), and Garigal National Park (Sheringham & Sanders 1993). Extensive species lists have been compiled for some areas, generally during the course of specific local vegetation studies.

Species recorded for major conservation areas are provided (see Table 3). Species lists for other sites have not been presented, though some may be listed in the bibliographies of floristic lists (Pickard 1972; Bryant & Benson 1981; Keith 1988; Benson & Melrose 1993). Botanical names used are those currently recognised at the National Herbarium of New South Wales. For authorities see Harden (1990–93).

Review of vegetation studies

Aboriginal people left no written records of the vegetation that supported them for thousands of years, though some of their names for plants and their uses were recorded by nineteenth century botanists such as Joseph Maiden (1889). Surprisingly, only a handful of Aboriginal names for Sydney plants have survived in current usage. Examples include Waratah, Geebung, Gynea, Mugga, Burrawang and Bangalay.

The scientific study of plants in the Sydney region began at Botany Bay in April 1770 when Joseph Banks and Daniel Solander landed from Captain Cook's *Endeavour* and described the 'rich and diverse flora'. The influence of the botanist Joseph Banks was crucial in the selection of Sydney as the site for a settlement. His ongoing interest ensured continuing concern for accurate botanical study and plant collection in the colony. Other professional botanists and botanical collectors were often based with colonial governors and included in exploring parties. Among these were George Caley, who was employed in the colony from 1800–1810 by Joseph Banks, and Allan Cunningham, collector for the Royal Botanic Gardens at Kew from 1817 and Colonial Botanist and Superintendent of the Sydney Botanic Gardens in 1837. As botanical collector Cunningham accompanied John Oxley and Philip King on early expeditions (1817–1822), and later himself explored parts of northern New South Wales and the Darling Downs of Queensland. Being primarily botanical collectors for overseas herbaria, such workers published very little themselves, but some of the diaries they kept have been subsequently published e.g. see Lee (1925) for Cunningham, and Andrews (1984) and Currey (1966) for Caley.

The European explorers and settlers were concerned with the agricultural value of the new country and used the vegetation as an indicator of its potential. They were also concerned with any likely vegetable products such as timber or food plants that could be of use to them. Most of the published accounts of explorers and visitors to the colony contain some references to the vegetation, though these accounts are of variable quality. Botanical names are used infrequently and identification of plant species is often difficult or impossible.

Baron Ferdinand von Mueller was the outstanding colonial botanist of the second half of the nineteenth century, and collectors sent many specimens to him in Melbourne. Among local Sydney collectors were the Reverend William Woolls, who published a number of lists of local Parramatta species, and Louisa Atkinson, who made collections at Berrima and Kurrajong, though most of their collections went either to Europe or Melbourne. Most of the collections now readily available to researchers in New South Wales date from the establishment of the National Herbarium of New South Wales in the 1880s by the Director of the Sydney Botanic Gardens, Charles

Moore. Moore's successor, Joseph Henry Maiden, was a very active botanist and enthusiastically developed the National Herbarium of New South Wales as a national collection. He concentrated on taxonomic work, and in particular the eucalypts, but also published papers on aspects of ecology. Sydney botanists published mainly through the journals of the Linnean Society of New South Wales and the Royal Society of New South Wales.

A.A. Hamilton's *Topographical, ecological and taxonomic notes of the ocean shoreline vegetation of Port Jackson* (1918) and *Ecological study of the saltmarsh vegetation in the Port Jackson district* (1919) are probably the first major descriptive ecological papers for the Sydney area. These were followed by papers on the ecology of the vegetation at Mount Wilson (Brough, McLuckie & Petrie 1924; Petrie 1925; McLuckie & Petrie 1926), Bulli (Davis 1936, 1941a, 1941b) and on the New South Wales Central Coast (Pidgeon 1937, 1938, 1940, 1941). In a series of major papers, Ilma Pidgeon described the general differences in vegetation on Wianamatta Shale and Hawkesbury Sandstone in terms of a series of plant communities in various stages of succession, the



Figure 3. J. H. Maiden, an early Director of the Royal Botanic Gardens Sydney, saw the value of conserving native vegetation, and it is largely due to his foresight that these remnant *Casuarina glauca* trees still survive in the Sydney Gardens today. This species rootsuckers vigorously, and these trees are probably genetically identical with the pre-1788 trees here.

stages being related to physiographic and moisture conditions. She did not include maps, but provided detailed descriptions of the plant communities, in particular of the Hawkesbury Sandstone of the Hornsby Plateau. Phillips (1947) complemented this work with descriptions of the main plant communities of the Wianamatta Shale.

Interest then turned towards the role of soil nutrients. Nola Hannon (1956, 1958) examined the role of soil nitrogen. N.C.W. Beadle (1953, 1962, 1966) demonstrated that the distribution of major vegetation types around Sydney relates largely to the differing levels of soil nutrients, particularly phosphorus, essentially derived from the parent material. Smaller-scale variation was related to physiographic factors. Rainforest vegetation is generally confined to soils with higher phosphorus levels while the sclerophyll vegetation occurs on soils with very low phosphorus levels. Increased soil nutrients in run-off from disturbed areas may promote exotic weed invasion in naturally low-nutrient sites (Clements 1983).

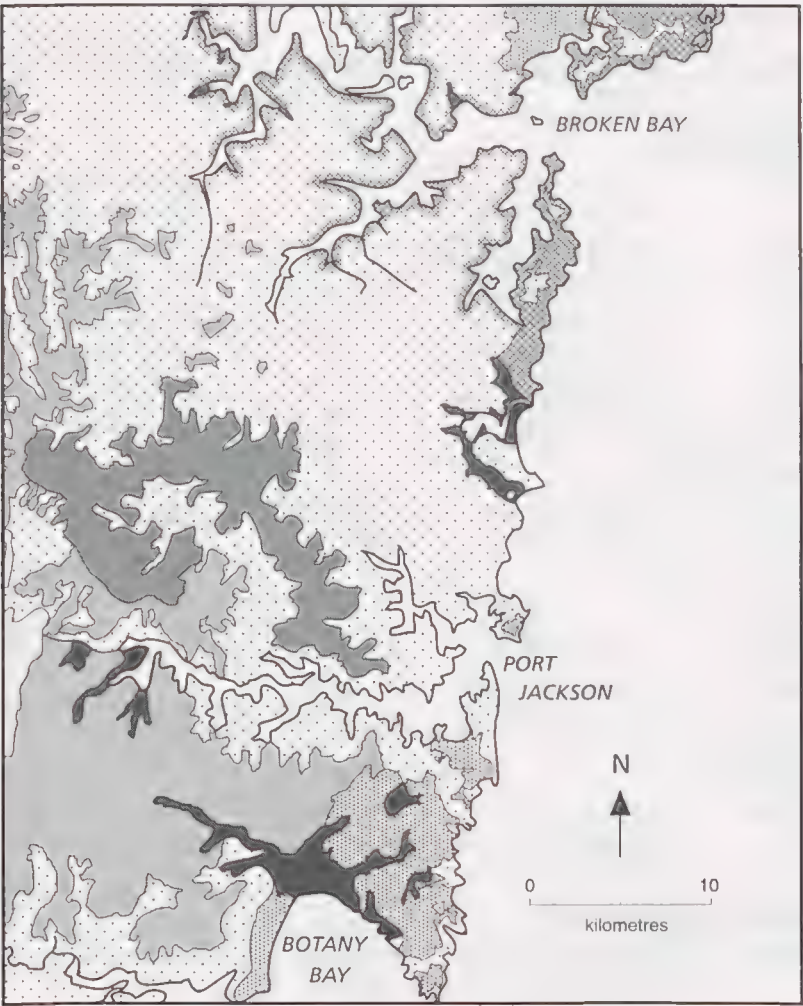
Recent interest in Sydney vegetation, as a result of the general awareness of conservation issues, has led to many local vegetation surveys and inventories (see Pickard 1972, Bryant & Benson 1981, Keith 1988, National Trust 1991, Benson & Melrose 1993), and to the vegetation surveys in the Sydney Region Vegetation Map Series. Accounts of the vegetation with particular reference to changes over the past 200 years include Benson and Howell (1990b) and in particular *Taken for granted* (Benson & Howell 1990a). As the present map sheet deals with about half of the area covered by Benson and Howell (1990a), the relationship between the eight general vegetation types described there and the map units described here is given in Table 1. A modified section of their map showing the extent of natural vegetation in 1788 for the Sydney map area is given in Figure 1.

As well as survey and descriptive studies, there has also been increasing and much-needed work on problems associated with conservation biology and natural area management. In particular, aspects such as fire (e.g. Bradstock & Myerscough 1981), soil nutrients and the spread of exotic weeds, and studies on the ecology of individual species (e.g. Auld & Myerscough 1986, Auld 1986) are now receiving due attention. We also hope to make ecological data on individual plant species more accessible through the Ecology of Sydney Plant Species project (Benson & McDougall 1993).

Table 1. Vegetation types in *Taken for granted*, Benson and Howell (1990a) (in bold type) with corresponding Sydney map sheet map units and codes.

Blue Gum High Forest	Duffys Forest 9sf
Blue Gum High Forest 6b	Coastal Clay Heath 21a
	Coastal Sandstone Heath 21g
Turpentine–Ironbark Forest	Eastern Suburbs Banksia Scrub
Turpentine–Ironbark Forest 9o	Coastal Dune Forest 9t
	Coastal Dune Heath 21b
Cumberland Plain Woodlands	Freshwater and Estuarine wetlands
Transition Forest 9d	Estuarine Complex 4a
	Coastal Swamp Forest Complex 27a
Sandstone heaths, woodlands and forests	Freshwater Reed Swamps 28a
Sydney Sandstone Gully Forest 10ag	
Sydney Sandstone Ridgetop Woodland 10ar	

Glen Forest 6c, Spotted Gum–Blackbutt Forest 9g and Narrabeen Slopes Forest 9h were not treated separately in *Taken For Granted*.



Natural Vegetation 1788

- Blue Gum High Forest (map unit 6b)
- Turpentine–Ironbark Forest (map unit 9o)
- Cumberland Plain Woodlands (map unit 9d)
- Eastern Suburbs *Banksia* Scrub (map units 9t, 21b)
- Estuarine and Freshwater Wetlands (map units 4a, 27a, 28a)
- Sandstone Heaths, Woodlands and Forests (map units 9sf, 10ag, 10ar, 21g)
- Narrabeen Group Forests (map units 9g, 9h, 21a)

Figure 4. Presumed 1788 or pre-European pattern of natural vegetation of the Sydney map sheet area.

Table 2. Map unit, common name, structure, main canopy species, geology and occurrence for plant communities in the area covered by the Sydney 1:100 000 map sheet

Map unit description

Map unit	Structure	Main canopy species	Geology	Occurrence
4a Estuarine Complex				
	Open-scrub	<i>Avicennia marina</i> <i>Aegiceras corniculatum</i>	Holocene alluvium	Estuarine mudflats, regular tidal inundation
	Herbland	<i>Sarcocornia quinqueflora</i> <i>Suaeda australis</i>	"	Occasional tidal inundation
	Rushland	<i>Juncus kraussii</i> <i>Phragmites australis</i>	"	Infrequent tidal inundation; brackish water
	Low open-forest	<i>Casuarina glauca</i> <i>Baumea juncea</i>	"	Poorly-drained, some saline influence
6b Blue Gum High Forest				
	Tall open-forest/ Open-forest	<i>Eucalyptus pilularis</i> <i>Eucalyptus saligna</i>	Wianamatta Shale	Broad ridges with residual shale soils North Shore to Hornsby
6c Glen Forest				
	Tall open-forest	<i>Eucalyptus saligna</i>	Diatremes	Isolated valleys
	Tall open-forest	<i>Eucalyptus agglomerata</i> <i>Angophora floribunda</i>	"	"
9d Transition Forest				
	Open-forest	<i>Eucalyptus fibrosa</i> <i>Eucalyptus moluccana</i> <i>Melaleuca decora</i>	Wianamatta Shale	Auburn
9g Spotted Gum-Blackbutt Forest				
	Open-forest	<i>Eucalyptus gummifera</i> <i>Eucalyptus maculata</i> <i>Eucalyptus pilularis</i>	Narrabeen Group	Bouddi Peninsula
	Open-forest	<i>Eucalyptus maculata</i> <i>Eucalyptus paniculata</i>	"	Lower hillslopes, Warringah Peninsula
	Woodland	<i>Eucalyptus umbra</i> <i>Eucalyptus paniculata</i>	"	Exposed slopes, Bouddi Peninsula
	Open-forest	<i>Archontophoenix cunninghamiana</i>	"	Deep gullies, Bouddi Peninsula
9h Narrabeen Slopes Forest				
	Open-forest	<i>Eucalyptus deanei</i> <i>Angophora floribunda</i>	Narrabeen Group	Lower hillslopes, Broken Bay-Hawkesbury River
	Open-forest	<i>Angophora floribunda</i> <i>Allocasuarina torulosa</i>	"	"

Map Structure unit	Main canopy species	Geology	Occurrence
9o Turpentine-Ironbark Forest			
Open-forest	<i>Syncarpia glomulifera</i> <i>Eucalyptus paniculata</i>	Wianamatta Shale soils	Inner western Sydney, lower rainfall between Glenorie and Ryde; often near junction with sandstone
9sf Duffys Forest			
Open-forest	<i>Eucalyptus sieberi</i> <i>Eucalyptus capitellata</i> <i>Eucalyptus gummifera</i> <i>Angophora costata</i>	Wianamatta Shale–Hawkesbury Sandstone	Residual plateau remnants with ironstone gravels
9t Coastal Dune Forest			
Open-forest	<i>Eucalyptus botryoides</i> <i>Eucalyptus pilularis</i> <i>Angophora costata</i>	Holocene Sand	Ramsgate La Perouse
Sydney Sandstone Complex			
10ag Sydney Sandstone Gully Forest			
Open-forest/ woodland	<i>Eucalyptus piperita</i> <i>Angophora costata</i> <i>Eucalyptus gummifera</i>	Hawkesbury Sandstone	Sheltered hillsides, gullies
Tall open-forest	<i>Eucalyptus pilularis</i> <i>Syncarpia glomulifera</i>	"	Gullies sheltered aspects
Closed-forest	<i>Ceratopetalum apetalum</i> <i>Tristaniopsis laurina</i>	"	Sheltered gullies
Sydney Sandstone Complex			
10ar Sydney Sandstone Ridgetop Woodland			
Woodland/ Low woodland	<i>Eucalyptus gummifera</i> <i>Eucalyptus haemastoma</i> <i>Eucalyptus sparsifolia</i> <i>Eucalyptus racemosa</i>	Hawkesbury Sandstone	Ridges, plateaus and dry, exposed hillsides
Woodland/ Low woodland	<i>Eucalyptus eximia</i> <i>Eucalyptus gummifera</i> <i>Angophora bakeri</i>	"	Ridges, plateaus, northwest of area
Open-scrub	<i>Banksia ericifolia</i> <i>Hakea teretifolia</i>	"	Poorly-drained sites
21a Coastal Clay Heath			
Open-heath	<i>Allocasuarina distyla</i>	Narrabeen Group	Long Reef to Bouddi
Grassland	<i>Themeda australis</i>	"	"
21b Coastal Dune Heath			
Open-heath	<i>Banksia aemula</i>	Pleistocene Sand	Coastal dunes, Bouddi, North Head, La Perouse
Open-scrub	<i>Monotoca elliptica</i>	"	"

Map Structure unit	Main canopy species	Geology	Occurrence
Open-scrub	<i>Banksia integrifolia</i> <i>Leptospermum laevigatum</i>		
21g Coastal Sandstone Heath			
Shrubland	<i>Baeckea imbricata</i>	Hawkesbury Sandstone	Shoreline heath
Open-heath/ Closed-scrub	<i>Banksia ericifolia</i> <i>Darwinia fascicularis</i>	"	Coastal heath, sandy shallow, soils
Open-heath/ closed-scrub	<i>Allocasuarina distyla</i> <i>Banksia ericifolia</i>	"	Widespread, shallow sandy, often poorly-drained soils
Open-heath	<i>Baeckea diosmifolia</i> <i>Baeckea brevifolia</i>	"	Rocky outcrop heath
Open-heath	<i>Hakea teretifolia</i> <i>Banksia oblongifolia</i>	"	Wet heath, poorly-drained
Sedgeland/ shrubland	<i>Banksia robur</i> <i>Viminaria juncea</i> <i>Gymnoschoenus sphaerocephalus</i>	"	Swamps, impeded drainage
Open-scrub	<i>Angophora hispida</i>	"	Drier areas
Shrubland (mallee)	<i>Eucalyptus luehmanniana</i>	"	Shallow soils, permanent seepage
27a Coastal Swamp Forest Complex			
Open-forest	<i>Eucalyptus botryoides</i> <i>Eucalyptus robusta</i>	Holocene stream alluvium & estuarine sediment	Creekflats or impeded drainage, Warringah Peninsula
Open-forest	<i>Livistona australis</i>	"	"
Scrub	<i>Melaleuca linariifolia</i> <i>Melaleuca styphelioides</i>	"	"
Reedland	<i>Phragmites australis</i> <i>Typha orientalis</i>	"	"
Herbland	<i>Persicaria strigosa</i> <i>Blechnum camfieldii</i> <i>Triglochin procera</i> <i>Baumea juncea</i>	"	Impeded drainage
28c Coastal Freshwater Swamp			
Open-sedgeland	<i>Eleocharis sphacelata</i> <i>Baumea juncea</i> <i>Persicaria decipiens</i>	Holocene marine sand & sandy peat	Botany Swamps, Centennial Park
Low open-forest	<i>Melaleuca quinquenervia</i>	"	"

C Cleared

These areas are mostly suburban development. Small remnants of vegetation too small to map may occur here.

Description of map units

A summary of the plant communities recognised in the Sydney 1:100 000 sheet area, their structural formation, main canopy species and geological substrate and occurrence is given in Table 2. The map unit numbering system applies to all maps in the Sydney Region Vegetation Map Series, missing numbers being communities which do not occur in the Sydney map area.

Map unit 4a

Estuarine Complex

Small patches of estuarine vegetation are found on alluvial mudflats (Holocene sand, silt and clay deposits) subject to varying degrees of tidal inundation. 'For it is strikingly singular that three such noble harbours as Botany Bay, Port Jackson, and Broken Bay, alike end in shallows and swamps, filled with mangroves' wrote Watkin Tench in 1788 (Tench 1979). Today such vegetation still occurs in Broken Bay and the lower Hawkesbury River, Port Jackson and the Parramatta and Lane Cove Rivers and Botany Bay and the Georges River. It generally consists of a sequence of zones of different structure and floristics related to duration of tidal inundation and salinity. The following zones may be recognised, though not all will necessarily occur at any one site.

i) Open-scrub of *Avicennia marina*–*Aegiceras corniculatum*. confined to the seaward edge of the mudflat and made up of mangroves (1–5 m high) of the Grey Mangrove, *Avicennia marina* and the smaller, River Mangrove, *Aegiceras corniculatum*. Mangroves generally receive daily tidal inundation.

ii) Herbland of *Sarcocornia quinqueflora*–*Suaeda australis*. a zone of saltmarsh, a herbland dominated by the succulent stemmed members of the Chenopodiaceae, *Sarcocornia quinqueflora* and *Suaeda australis*.

iii) Rushland of *Juncus kraussii* and *Phragmites australis*. These areas have brackish water and receive infrequent tidal inundation.

iv) Low open-forest of *Casuarina glauca* and *Baumea juncea*. Areas with saline soils and periodic flooding. Swamp forest with *Eucalyptus robusta* may occur on alluvium at the landward end of the zonation (see Map Unit 27a Coastal Swamp Forest Complex).

The nature of the surrounding country may influence the floristic composition. Estuarine areas on the southern side of the Parramatta River drain from low-relief country with clay soils from Wianamatta Shale. The clayey alluvium originally supported saltmarsh interspersed with broad bare mudflat areas, only infrequently flooded and described at Homebush Bay as the dry salt plain by Hamilton (1919). The senior author remembers these sites from his schoolday explorations in the early 1960s. These clay rich mudflats, remnants of which still survive at Homebush Bay, included species such as *Lampranthus tegens*, *Wilsonia backhousei* and *Halosarcia pergranulata* subsp. *pergranulata*, not generally found in other saltmarsh areas (Clarke & Benson 1988). For example the major saltmarsh reserves at Towra point are on more sandy alluvium and do not include these dry salt-plain species. Extensive areas of these estuarine mudflats in the upper Parramatta River in Concord and Auburn municipalities and along the Cooks River in Marrickville, were destroyed by landfill between 1920 and 1970. A potential longterm threat to saltmarsh vegetation comes from the spread of the weed *Juncus acutus*, now established at Homebush Bay and Saltpan Creek.

Along the Lane Cove River and the northern side of the Parramatta River, as well as Broken Bay and the Hawkesbury River, including the lower reaches of its tributary creeks downstream from Wisemans Ferry, much of the alluvial material is sandy, being derived from the nearby Hawkesbury Sandstone. The adjacent hillslopes are generally much steeper, and estuarine areas are much more limited; mangroves predominate, saltmarsh areas are of only limited extent. Where sandstone hillsides drop sharply into the water with no build-up of alluvium, the zonation may be truncated to a line of

mangroves and a few trees of *Casuarina glauca*. In the Lane Cove River agricultural and particularly urban development in the catchment has increased sedimentation and allowed mangroves, particularly *Avicennia marina* populations to expand seawards (McLoughlin 1985, Thorogood 1985), though similar expansion of saltmarsh has not been recorded. Saltmarsh and landward vegetation such as *Juncus kraussii* and *Casuarina glauca* has generally declined as a result of landfilling.

Coastal lagoons at Narrabeen and Dee Why (Coveny g), have some small remaining areas, principally of rushland, while limited stands of estuarine low open-forest persist at Warriewood.

Within the Sydney map area, descriptions of estuarine vegetation have been compiled for Brisbane Water National Park (Benson & Fallding 1981); Muogamarra Nature Reserve (Thomas & Benson 1985b); Ku-ring-gai Chase National Park (Thomas & Benson 1985a) Calna and Berowra Creeks (Pickard 1974), Smiths Creek, Terrey Hills (Kratovich et al. 1973), Port Jackson and the Cooks River (Hamilton 1919), Bantry Bay (Upper Middle Harbour Conservation Committee 1974), Homebush Bay (Centre for Environmental Studies, 1978; Clarke & Benson 1988, Adam 1991, Kachka 1993), the Lane Cove River (McLoughlin 1985), Wolli Creek (Allaway & Clarke 1987, Brown et al. 1988).

A wealth of observations on the behaviour of saltmarsh species, together with descriptions of vegetation in areas where it has long since been removed, such as Cooks River, are given in Hamilton (1919). Detailed studies of mangrove and saltmarsh communities and individual species at Towra Point, an important estuarine area on the southern shore of Botany Bay but outside the Sydney map area, have been carried out by Clarke and Hannon (1967, 1969, 1970, 1971).

Map Unit 6b

Blue Gum High Forest

Tall open-forest–open-forest: *Eucalyptus pilularis*–*Eucalyptus saligna*

This was the original vegetation of the higher rainfall (above 1100 mm p.a.) Wianamatta Shale soils of Sydney's north shore suburbs (Benson & Howell 1990a). The original forest was composed of big trees, probably over 40 m in height, and it was

obviously a valuable source of timber last century. For example Raymond (1832) describes land near Pennant Hills let on lease for the purpose of cutting timber: 'Their leases are nearly expired. Much fine timber still remains, the trees along this range being in general of an uncommonly large size, perhaps more so than in any other part of Cumberland, and therefore very advantageously situated so near a rapidly increasing town.'

Eucalyptus pilularis and *Eucalyptus saligna* are the main trees, originally probably in excess of 30 m tall. Other tree species include *Angophora costata*, *Eucalyptus paniculata*, *Eucalyptus globoidea* and *Syncarpia glomulifera*. An open, small-tree layer of saplings of canopy tree species and mature individuals of *Allocasuarina torulosa* is often present on drier sites, or *Pittosporum undulatum* on moister ones.

Shrubs are common, and often form a dense cover. Common species on drier sites are *Platylobium formosum*, *Leucopogon juniperinus*, *Dodonaea triquetra* and *Hibbertia aspera*. On moister sites and in depressions these shrubs are replaced by ferns, particularly *Calochlaena (Culcita) dubia*, *Adiantum aethiopicum* and *Doodia aspera*, and shrubs with softer leaves, such as *Breynia oblongifolia* and *Polyscias sambucifolius*.

Mesic shrubs may line shallow water courses but 'rainforest-type' understorey rarely occurs on the shale soils, as the deep, sheltered gullies required for the best development of these species cut through the thin shale capping to the low nutrient Hawkesbury Sandstone soils below. 'Rainforest-type' gully vegetation in the area is therefore generally on sandstone though this may be enriched by shale material washed down from the ridges. On the shale soils there were patches of wetter understorey on sheltered hillsides, but localised rainforest understorey patches only occur at Brush Farm at Eastwood where an unusual combination of rich soils, unusually deep, sheltered gullies, and a high rainfall allowed rainforest species to survive. Species here include *Acmena smithii*, *Cryptocarya glaucescens*, *Guioa semiglaucula*, *Schizomeria ovata*, *Rhodamnia rubescens* and *Euodia micrococca* (Coveny a, Broadbent & Buchanan 1984, Benson 1986b).

Blue Gum High Forest was an important resource to the timber-getters who cut out much of the valuable Blackbutt and Blue Gum in the nineteenth



Figure 5. Remnant Blue Gum High Forest, map unit 6b, with *Eucalyptus saligna* at Dalrymple-Hay Nature Reserve, St Ives.

century (Hawkins 1994). Clearing and agricultural development led to dairy farms and orchards and then suburban development. Most of Sydney's Blue Gum High Forest has now been destroyed; Benson and Howell (1990b) estimated that only 0.9% of the original 11 000 ha found in the County of Cumberland remained in 1980). There are still some small remnants. In particular, in two reserves, Dalrymple Hay Nature Reserve at St Ives (Benson & Keith 1984a) and Ludovic Blackwood Memorial Sanctuary at Beecroft (Buchanan 1977, 1978), and in a number of smaller areas, such as Sheldon Forest, Turramurra; Darvall Park, Denistone (Coveny e); Brush Farm Park, Eastwood where there is an important remnant of rainforest (Coveny a, Broadbent & Buchanan 1984, Benson 1986b); Observatory Park, Beecroft; and Edna May Hunt Reserve, Eastwood (Benson 1979b). In addition, patches too small to map at the present scale [may] persist on roadsides or creek edges; it is important to protect these as they add to the areas of scarce habitat available for perpetuation of the forest's species.

Along creeks and drainage lines where remnants of this community still persist, there is often dense exotic weed growth invading and crowding out the

native species. *Ligustrum sinense* and *L. lucidum* (Privet species) are the main culprits, while *Tradescantia albiflora* (Wandering Jew) is another major problem species. This ground-cover plant smothers native ground species, prevents seedling recruitment and is very difficult to eradicate. The most effective control in bushland areas appears to be hand-weeding and careful herbicide use. Many native understorey species can persist as propagules in the soil, able to re-establish when conditions for germination and regrowth are favourable.

Map Unit 6c Glen Forest

Small volcanic necks or diatremes are scattered throughout the Sydney region, about 25 being shown on the Sydney 1:100 000 geology map (Herbert 1983). These sites have higher-nutrient soils than surrounding areas (Chapman & Murphy 1989) and their vegetation generally contrasts markedly with that on the adjacent sandstone or shale soils. Where the surrounding rock is low-nutrient sandstone these differences are particularly distinctive because of the differences in soil

nutrients, and because many such diatremes often occur in sheltered valley positions. Unfortunately most natural vegetation on diatremes in the immediate Sydney area has been destroyed, either because their fertile soils were cleared for agriculture, or because the basaltic rocks, a convenient source of blue metal aggregate, have been extensively quarried. Remnant diatreme vegetation indicates that considerable local differences in vegetation composition occurred between sites, mainly as a result of variations in soil type and exposure conditions; two sub-units are recognised below.

i) Tall open-forest: *Eucalyptus saligna*

Eucalyptus saligna dominated vegetation, very similar to the Blue Gum High Forest of the North Shore (map unit 6b), grew on high-nutrient volcanic soils under similar high rainfall conditions (1200–1400 mm p.a.). Old Mans Valley at Hornsby, probably the largest diatreme in the area, has been extensively quarried for blue metal aggregate, but remnant vegetation on nearby Joes Mountain in Berowra Valley Bushland Park (too small to map at 1:100 000 scale) has *Eucalyptus saligna* as the dominant tree species with less frequent trees of *Eucalyptus pilularis* and *Angophora floribunda*. Native understorey species include *Calochlaena dubia*, *Blechnum cartilagineum*, *Adiantum aethiopicum*, *Pteridium esculentum*, *Smilax australis*, *Pandorea pandorana* and *Poa affinis* (Smith & Smith 1990). Weeds constituted 14% of the species recorded in the survey plot including *Lonicera japonica*, which was codominant with *Calochlaena* in the dense fern layer, and *Ligustrum lucidum*, *Ligustrum sinense* and *Cinnamomum camphora* that were codominant in the shrub and low tree layers.

Similar high rainfall vegetation probably occurred on other diatremes such as at Browns Field (South Turramurra Environment Protection 1980), Dundas, Burwood and Lugarno. Volcanic necks in the Blue Mountains with similar vegetation are known as Glens e.g. Murphys Glen, Tobys Glen (Keith & Benson 1988).

ii) Tall open-forest: *Eucalyptus agglomerata*–*Angophora floribunda*

In Ku-ring-gai Chase, the amphitheatre-shaped valley of Campbells Crater contains tall open-forest to open-forest with trees 15–35 m tall with a mid-

dense canopy cover. On the slopes of the crater the understorey is shrubby but the floor supports small trees, palms and tree ferns with a ground cover of monocotyledons and ferns. Vines are common (Thomas & Benson 1985a). Main tree species are *Eucalyptus agglomerata*, *Angophora floribunda*, *Allocasuarina torulosa*, also with *Angophora costata* and *Eucalyptus umbra*. Small trees include *Acacia floribunda*, *Synoum glandulosum* and the palm *Livistona australis*. Understorey species include shrubs; *Pultenaea flexilis*, *Prostanthera denticulata*, *Astrotricha floccosa*, and ground species; *Dianella caerulea*, *Oplismenus imbecillis*, *Calochlaena dubia*, *Hypolepis muelleri*, *Cyathea australis*, *Pteridium esculentum*, *Pseuderanthemum variabile*, *Hydrocotyle acutiloba*, *Goodenia ovata*, *Helichrysum elatum*, *Cissus hypoglaucia*, *Smilax australis*, *Pandorea pandorana* and *Cayratia clematidea*.

At Campbells Crater variation relates to slope, soil and aspect. The understorey changes between the sides and the floor of the crater. On the sides a sandy topsoil lies over a clay sub-soil and this tends to support a denser shrub layer than the hard clay soil on the crater floor. The lower south-facing slope of the crater has a dense fern understorey, while the east- and north-facing slopes have a more open understorey. Weed infestation is heavy on the crater floor where the soil is more fertile. Species that are absent or uncommon elsewhere in Ku-ring-gai Chase National Park are *Eucalyptus agglomerata*, *Toona ciliata*, *Seringia arborescens*, *Asterolasia correifolia*, *Rulingia dasyphylla* and *Rubus rosifolius*.

Remnants of similar vegetation occur at Dillons Crater in Brisbane Water National Park (Benson & Fallding 1981) and Peats Crater in Muogamarra Nature Reserve, though much of the volcanic areas have been cleared. Blanch and Marramarra Craters in Marramarra National Park, and one north of Fiddletown (Smith & Smith 1990), probably still have similar vegetation.

Volcanic dykes also occur, but are generally too narrow to support a distinct plant community, though understorey species may show local variations indicative of the more clayey, higher-nutrient soils. Sanders (1983) found that wide variation occurred within the vegetation associated with dykes and that soil and topographic position were important factors for species distribution; soil move-

ment downslope from the dyke accounts for 'dyke' vegetation growing on sandstone. On soils associated with a dyke at West Head is open-forest with trees of *Eucalyptus paniculata*, *Eucalyptus umbra*, *Angophora floribunda*, *Eucalyptus scias* subsp. *scias*, *Syncarpia glomulifera* and *Allocasuarina torulosa*. Six species were found to characterise the vegetation on the ridge: *Macrozamia spiralis*, *Xylomelum pyriforme*, *Lomatia silaifolia*, *Pultenaea daphnoides*, *Notelaea ovata* and *Breynia oblongifolia*; and three to characterise the basalt soil in the creek; *Cissus hypoglauca*, *Doodia aspera* and *Livistona australis*.

Map Unit 9d

Transition Forest

Open-forest: *Eucalyptus fibrosa*–*Eucalyptus moluccana*–*Melaleuca decora*

Found in the Bankstown–Regents Park area, small patches of this vegetation still exist around Duck River, Auburn and Rookwood Cemetery, occurring on lower rainfall Wianamatta Shale (rainfall at Lidcombe is about 800 mm p.a.) on soils often associated with ironstone gravels, generally red podzolics or relict red podzolics. These are of low fertility and support vegetation with a shrubby understorey rather than the grasses that are characteristic of the more fertile soils of the Cumberland Plain with a similar rainfall. Floristically this vegetation is similar to the open-forest on transitions from Wianamatta Shale to the Tertiary alluvium in the Castlereagh–Penrith area and mapped (map unit 9d) on the Penrith Sheet (Benson 1992a), although here it is on Wianamatta Shale. It is likely that similar soil and drainage conditions here support this vegetation.

Structure is open-forest with an understorey ranging from a dense shrub layer about 3 m high to open and grassy with scattered shrubs. In the Bankstown–Regents Park area the main canopy tree species are *Eucalyptus fibrosa* and *Eucalyptus moluccana*. *Eucalyptus longifolia* and *Eucalyptus globoidea* occur sporadically and do not appear to be in any particular habitat. *Eucalyptus tereticornis* is found in the lower rainfall areas generally on lower hill slopes and depressions. *Syncarpia glomulifera* is usually found in higher-rainfall areas. *Angophora bakeri* was recorded only from near Duck River at Auburn, and *Eucalyptus parramattensis* from Bass Hill.

Dense shrubs are found along watercourses. *Melaleuca decora* is common in depressions and on poorly-drained flats. *Melaleuca styphelioides* is less common and found along creek channels. Other shrub species along creeks include *Rapanea variabilis* and *Breynia oblongifolia*. Shrubs also predominate on dry gravelly rises. Of the larger shrubs *Bursaria spinosa*, *Melaleuca nodosa* and *Acacia decurrens* are most common. Smaller shrubs include *Lissanthe strigosa*, *Daviesia ulicifolia*, *Dillwynia juniperina*, *Callistemon pinifolius*, *Acacia pubescens* and *Dodonaea triquetra*. Ground plants, grasses such as *Themeda australis* and *Aristida vagans*, sedges such as *Lepidosperma laterale* and *Lomandra longifolia* and herbs such as *Vernonia cinerea*, *Pratia purpurascens* and *Hardenbergia violacea* are interspersed with the shrubs or are more conspicuous on the sides of gravelly ridges.

Price (1979) studied the remnants of native vegetation in the Auburn area. He found that the original forest structure at Duck River and Rookwood Cemetery has been largely modified by fire, since European settlement, into grasslands, *Melaleuca* and eucalypt scrub, and low woodland. Grasslands dominated by *Themeda australis* occur in areas cleared long ago and little interfered with other than by regular burning. Other species associated with them include *Patersonia longifolia*, *Hypoxis hygrometrica*, *Xanthorrhoea* and *Lomandra* species and ground orchid species of *Diuris*, *Microtis* and *Thelymitra*.

Melaleuca and eucalypt scrub is common on land that has been partly cleared or left to recolonise naturally. *Melaleuca decora*, *Melaleuca nodosa* and *Melaleuca styphelioides* are the most abundant shrub species here and may be accompanied by small trees of *Eucalyptus fibrosa*, *Eucalyptus moluccana*, *Eucalyptus resinifera*, *Angophora bakeri*, *Syncarpia glomulifera* and *Eucalyptus longifolia*. Depending on the density of the *Melaleuca* canopy, there may be scattered herbs or open grassy places in between. Herb species include *Stylidium graminifolium*, *Lomandra* species, *Dianella* species, *Calotis cuneifolia* and *Vernonia cinerea*. Shrubs of open places such as *Daviesia ulicifolia*, *Dillwynia juniperina*, *Indigofera australis*, *Pimelea linifolia*, *Olearia microphylla*, *Ozothamnus diosmifolius*, *Bursaria spinosa*, *Callistemon linearis*, *C. pinifolius*, and the low-growing *Melaleuca* species, *Melaleuca erubescens* and *Melaleuca thymifolia*, are usually

more common than species found in more shady habitats, such as *Polyscias sambucifolius*, *Pittosporum undulatum* and *Breynia oblongifolia*. Fire modifies the structure and floristics of these *Melaleuca* scrubs. When the canopy is opened to light, short-lived herbs such as *Pelargonium inodorum*, *Polymeria calycina*, *Senecio hispidulus* and shrub species *Cassinia arcuata*, *Ozothamnus diosmifolius*, *Olearia microphylla*, *Pimelea linifolia*, *Pultenaea villosa*, *Acacia falcata* and *Acacia longifolia*, establish.

The understorey of shrubs and tall herbs in the low woodland remnants include shade-tolerant or moisture-requiring species, many of them having seeds that are probably spread by birds. Species able to survive fires by suckering, such as *Breynia oblongifolia*, *Phyllanthus gasstroemii*, *Rapanea variabilis*, *Notelaea longifolia* and the exotic weed species *Asparagus officinalis* and *Myrsiphyllum asparagoides* are most abundant; other species include *Glochidion ferdinandi*, *Pittosporum undulatum*, *P. revolutum* and *Omalanthus populi-folius*. For the Auburn area Price recorded 292

native species, a considerable number in view of the degree of disturbance the area has suffered.

This vegetation occurs on very poor agricultural soils. It remained largely undisturbed until the expansion of suburban development in the Bankstown–Liverpool district following the Second World War. Remnants still survive on State, Commonwealth and local council land. Probably the best example in the map area is along Duck River at Auburn. There are also remnants at Rookwood Cemetery, Carysfield Park at Bass Hill, Norfolk Reserve, Greenacre, and Airport and Ashford Reserves, Milperra. A nationally listed rare species, *Acacia pubescens*, is almost completely restricted to this community and has been recorded at a number of sites in the area including Carysfield Park and Rookwood Cemetery and along the railway line near Punchbowl and Yagoona. Trees of *Eucalyptus longifolia* with *Melaleuca decora* still survive beside Parramatta Road at its intersection with Hill Road, Granville. These are significant because they are the last naturally occurring native trees along Parramatta Road between Sydney and Parramatta.



Figure 6. *Eucalyptus maculata* open-forest, map unit 9g(ii), on the lower slopes at Elvina Bay, western Pittwater.

Map unit 9g

Spotted Gum–Blackbutt Forest

Spotted Gum–Blackbutt Forest is a very extensive and varied community on the Gosford map sheet area (Benson 1986a). It is an important component of the forestry activities of the Wyong district and extends south along the coast into the Bouddi and Warringah Peninsulas on the Sydney map sheet, where *Eucalyptus maculata*, Spotted Gum, is particularly conspicuous. Here, spotted Gum–Blackbutt Forest is found along the entrance to Brisbane Water between Wagstaff and The Rip (McRae 1990), along the Warringah Peninsula, on Scotland Island, and on the foreshores of Pittwater (Pidgeon 1937; Thomas & Benson 1985a). It is found on lower hillslopes on the Narrabeen Group–Terrigal Formation and coastal occurrences of the Newport Formations (interbedded laminite, shale and sandstones), on shallow to deep lithosols and podzolics of the Watagan Soil Landscape (Chapman & Murphy 1989). Annual rainfall here is up to 1500 mm with no winter frosts or seasonal drought (Kartzoff 1969). A number of sub-units can be recognised.

i) Open-forest: *Eucalyptus gummifera*–*Eucalyptus maculata*–*Eucalyptus pilularis*

Occurs mainly in the Wyong area on the Gosford map sheet (Benson 1986a).

ii) Open-forest: *Eucalyptus maculata*–*Eucalyptus paniculata*

Eucalyptus maculata, Spotted Gum, is the most characteristic tree, e.g. making up 46% of a sample of 150 trees in Hudson Park, Avalon (Smith & Smith 1993), forming an open-forest 15–30 m high with a mid-dense canopy cover. Associated trees at Hudson Park are *Angophora costata* (16%), *Eucalyptus gummifera* (13%), *Eucalyptus umbra* (9%), *Eucalyptus punctata* (6%), *Eucalyptus paniculata* (4%), *Syncarpia glomulifera* (3%), *Eucalyptus botryoides* (2%) and *Angophora floribunda* (1%). Small trees include *Allocasuarina torulosa*, *Glochidion ferdinandi* and *Livistona australis*. The understorey varies according to aspect. On dry sites there is a very sparse small tree and shrub layer with *Allocasuarina littoralis*, *Dodonaea triquetra*, *Platylobium formosum*, *Macrozamia communis* and *Pultenaea flexilis*, a mid-dense low shrub layer and an open ground cover of herbs and graminoids. In

sheltered aspects the small tree layer is denser, including *Elaeocarpus reticulatus* and *Pittosporum undulatum*, there are few low shrubs, and ferns such as *Adiantum aethiopicum* and *Doodia caudata*, and vines such as *Cissus hypoglauca*, *Pandorea pandorana*, *Cayratia clematidea*, *Geitonoplesium cymosum* and *Eustrephus latifolius* may form a 'rainforest type' understorey. Small rainforest trees may occur, particularly on the Warringah Peninsula, including *Diospyros australis*, *Synoum glandulosum*, *Cassine australis* var. *australis*, *Euodia micrococca*, *Commersonia fraseri* and *Alphitonia excelsa*. *Livistona australis* is locally abundant around Bilgola.

Floristic lists have been compiled for Angophora Reserve and Hudson Park, Avalon (Table 3, Smith & Smith 1993), the National Trust's Burley Griffin Lodge at Avalon (Buchanan 1979b), western Pittwater (Thomas & Benson 1985a), and Loquat Valley, Bayview (Costin 1986).

iii) Woodland: *Eucalyptus umbra*–*Eucalyptus paniculata*

Related vegetation is found on the south-eastern side of the Bouddi Peninsula on slopes running from the main ridge to the coast (McRae 1990). Here the slopes are steep, from 10° to 35°, the aspect varies around south-east and there is always some degree of exposure to coastal winds and saltspray. Where the coastal exposure is greatest, the structure is reduced to a tall shrubland in which the canopy merges with the shrub layer. Elsewhere it is woodland structure.

The main tree species, *Eucalyptus umbra*, *Eucalyptus paniculata*, *Angophora costata* and *Syncarpia glomulifera* form a layer that varies from a height of 25 m and a cover of 25% to a height of 3 m with 10% cover, with increasing exposure. The shrub layer (3 m high with 20% cover) has a variable composition with common species including *Macrozamia communis*, *Dodonaea triquetra* and *Pultenaea flexilis*. The tall ground layer (1.5 m high with 30% ground cover) is dominated by *Lomandra longifolia*, *Imperata cylindrica*, *Gahnia melanocarpa* and *Pteridium esculentum*. The variability in all strata is due to aspect and soil, the latter arising from the variable nature of the parent rocks (McRae 1990).

iv) Open-forest: *Archontophoenix cunninghamiana*

On slopes below Mt Bouddi are deep gullies with marginal rainforest dominated by Bangalow Palm, *Archontophoenix cunninghamiana*, with scattered *Eucalyptus deanei* and *Allocasuarina torulosa* (McRae 1990). Structurally this is open-forest with the trees up to 30 m high and reaching 60% canopy cover. There is a small tree layer, 10 m high, with Cabbage Palm, *Livistona australis*, *Duboisia myoporoides*, *Glochidion ferdinandii*, *Ficus coronata*, *Pittosporum undulatum*, *Schizomeria ovata*, and *Acmena smithii*, scattered shrubs including *Notelaea venosa*, *Wilkiea huegiana*, *Eupomatia laurina* and *Citriobatus pauciflorus*, and ground cover species including *Cissus antarctica*, *Rubus moorei*, *Morinda jasminoides*, *Gymnostachys anceps* and *Blechnum cartilagineum*. *Lantana camara* is usually abundant in the surrounding eucalypt woodland and in time could increase from its currently isolated thickets within the palm-forests.

Map unit 9h

Narrabeen Slopes Forest

Narrabeen Slopes Forest is particularly characteristic of the foreshores of Broken Bay and Pittwater (communities 6 and 7 of Thomas & Benson 1985a) and along the Hawkesbury River and its tributaries, Mangrove and Mooney Mooney Creeks (Benson & Fallding 1981; Benson 1986a). Similar vegetation is found on lower slopes of the islands of Broken Bay — Spectacle Island (Webb 1981), Bar Island (Benson 1984), Milson Island (Cleland 1914) Lion Island (Benson 1981a), Long Island (Coveny & McDougall 1990) and Dangar Island, and Scotland Island in Pittwater. All of these islands, with the exception of Bar Island, have Hawkesbury Sandstone vegetation (map unit 10ar) on their crests.

Narrabeen Slopes Forest is found on strata of the Narrabeen Group–Newport Formation (interbedded shale, laminite and medium-grained quartz sandstone) that outcrop on lower slopes and hillsides below cliffs and ridges of Hawkesbury Sandstone. Vegetation structure and floristic composition are particularly influenced by aspect. South-facing slopes are steeper, cooler and moister than north-facing slopes, which are less steep, but drier and more sunny. Two sub-units are recognised.

i) Open-forest: *Eucalyptus deanei*–*Angophora floribunda*

Sheltered south-facing aspects generally have open-forest with trees of *Eucalyptus deanei* and *Angophora floribunda* and may be associated with pockets of rainforest. This is found mainly on the northern side of Broken Bay in Mooney Mooney and Mullet Creeks on the Gosford map sheet (Benson 1986a), with one small occurrence at the southern end of Brisbane Water National Park and near Patonga (community 2B of Benson & Fallding 1981). There is generally a mesic understorey with climbers — *Hibbertia scandens*, *Hibbertia dentata*, *Cissus hypoglauca*; ferns — *Calochlaena dubia*, *Doodia aspera*, *Pteridium esculentum*; and other ground species — *Themeda australis*, *Imperata cylindrica*, *Hydrocotyle* and *Lomandra* species.

ii) Open-forest: *Angophora floribunda*–*Allocasuarina torulosa*

On dry north- to west-facing slopes and on slopes open to sea breezes, open-forest is characterised by *Angophora floribunda*, *Eucalyptus punctata* and *Allocasuarina torulosa*. This occurs on the eastern sides of Mooney Mooney and Mullet Creeks in Brisbane Water National Park (community 2A of Benson & Fallding 1981), but is most common on the southern shore of Broken Bay on the foreshores of Cowan Creek, Coal and Candle Creek, Smiths Creek and the Hawkesbury River (Thomas & Benson 1985a, Community 7). Here it is from 15–25 m high with a mid-dense to open canopy cover. The main tree species are *Angophora floribunda*, *Eucalyptus punctata* and *Allocasuarina torulosa*, with *Eucalyptus botryoides*, *Eucalyptus umbra* and *Eucalyptus paniculata*. The understorey is usually dry with an open shrub layer and a ground cover dominated by grasses and herbs. Shrubs include *Pultenaea flexilis*, *Acacia ulicifolia*, *Astrotricha floccosa*, *Cassinia denticulata*, *Playsace linearifolia*, *Prostanthera denticulata* and *Persoonia linearis*. Grasses include *Entolasia* species and *Themeda australis*, and may predominate in frequently burned sites. On very sheltered aspects there may be moister species such as *Synoum glandulosum* and *Calochlaena dubia*.

Thomas and Benson (1985a) indicate that *Eucalyptus botryoides* and *Eucalyptus paniculata* occur with *Angophora floribunda* along the foreshores of Western Pittwater from McCarrs Creek to West

Head on deeper, heavier soils in sheltered sites (described as their community 6). This variant commonly has an understorey of *Calochlaena dubia* and vines, particularly *Smilax australis* and *Geitonoplesium cymosum*, and has been included within this map unit. *Eucalyptus botryoides* may extend beyond the Narrabeen Group soils and is commonly found with *Angophora costata* on coastal sandstone headlands but rarely occurs away from the coast. *Eucalyptus maculata* rarely occurs in this unit. However, it is found around Pittwater where Narrabeen Slopes Forest is similar to and intergrades with Spotted Gum–Blackbutt Forest (map unit 9g).

Map unit 9o

Turpentine–Ironbark Forest

Open-forest: *Syncarpia glomulifera*–*Eucalyptus paniculata*

Turpentine–Ironbark Forest was the characteristic forest vegetation of the inner western part of Sydney from St Peters west to Peakhurst and sporadically as far as Lansdowne. It occurred on Wianamatta Shale, on shallow to deep podzolic soils of the Blacktown Soil Landscape (Chapman & Murphy 1989). It was also found north of the Parramatta River, from Ryde to Castle Hill and along shale-capped ridges around Glenorie and Arcadia, and on the transition zone between the Wianamatta Shale and the underlying Hawkesbury Sandstone, particularly on soils formerly known as the Hammondville Association (Walker 1960).

Turpentine–Ironbark Forest was first described by Phillips (1947) as a sub-association (*Eucalyptus pilularis*–*Eucalyptus resinifera*) of her *Eucalyptus pilularis*–*Eucalyptus saligna* Association, but is distinctive enough to map and discuss as a separate unit. With a moderate rainfall of between 900 mm and 1100 mm per annum, the vegetation, an intermediate, is part of the shale-vegetation gradient from the higher-rainfall Blue Gum High Forest (*Eucalyptus pilularis*–*Eucalyptus saligna* tall open-forest, map unit 6b), to the low rainfall Grey Box Woodland (*Eucalyptus moluccana*–*Eucalyptus tereticornis* woodland, map unit 10c, Benson 1992) further west on the Cumberland Plain.

Most of the Turpentine–Ironbark Forest has now gone, having been replaced by suburbs in the

nineteenth and early twentieth centuries (Benson & Howell 1990a). Part of the Inner Western area, north of the Cooks River, in the Ashfield–Canterbury area was designated the *Kangaroo Ground* by Watkin Tench (Tench 1979), and was sought for early settlement. Collins (1798) wrote: 'The lieutenant-governor [Grose] proposing to open and cultivate the ground commonly known by the name of the Kangaroo Ground, situate to the westward of the town of Sydney between that



Figure 7. There are only a few surviving remnants of Turpentine–Ironbark Forest, map unit 9o, such as here at Fagan Park, Galston.

settlement and Parramatta, a gang of convicts was sent from the latter place for that purpose. The soil here was much better for agriculture than that immediately adjoining to the town of Sydney, and the ground lay well for cultivation; but it had hitherto been neglected, from its being deficient in the very essential requisite of water; on which account Parramatta had been preferred to it.'

This area would appear to have been eucalypt open-forest or woodland with an open understorey suitable for kangaroo habitat (Pratten 1993). There would, however, have been local variation in vegetation composition, and other early writers mention 'heavy timber and brush' (i.e. a dense understorey of shrubs). Peter Cunningham (1827) described Parramatta Road between Annandale and Ashfield bordered by land '... thickly covered with heavy timber and brush, the soil being usually a poor shallow reddish or ironstone clay, the contemplation whereof presents but little pleasure to the agriculturalist'.

Characteristic tree species were probably *Syncarpia glomulifera*, the Turpentine, and *Eucalyptus paniculata*, the Grey Ironbark. These would have been accompanied by a range of other species including *Eucalyptus globoidea*, *Eucalyptus punctata*, *Eucalyptus resinifera*, *Eucalyptus pilularis* and *Angophora floribunda*. Remnant trees of *Syncarpia glomulifera*, *Eucalyptus pilularis*, *Eucalyptus resinifera* and *Eucalyptus globoidea* still survive in Ashfield (Pratten 1993) and there are old herbarium collections of *Eucalyptus siderophloia* from Burwood and Belmore. A notice in the Sydney Morning Herald in December 1834, advertising allotments of the Burwood estate mentions 'timber: Shingle Oak, Iron and Stringy Bark, Mahogany, Blue Gum' etc. 'Blue Gum' here may refer to *Eucalyptus saligna*, which may have occurred locally in gullies or depressions, or *Eucalyptus tereticornis*, which may also have occurred.

Estimated canopy heights in remnant stands north of the Harbour, surveyed in the 1970s, ranged from 10 to 20 m with canopy cover from 30 to 67%, all figures characteristic of open-forest formation (D. Benson unpub. data). Most of these remnants are on the least favourable agricultural sites and have generally been logged, grazed and burnt at varying intensities. Plant densities for these stands, (mean = 719 ± 383 plants/ha), indicate a considerable amount of sapling and small tree regeneration. *Syncarpia*

glomulifera was the most important species, accounting for 16% of total basal area and 35% of total plant density, probably because of its ability to withstand disturbance by resprouting, and its slow growth. Seven other tree species each accounted for between 4 and 14% of total basal area and between 2 and 10% of total plant density. A further eight species were recorded contributing to total site basal area.

The understorey was variously shrubby or grassy. Common shrub species in remnants now are *Dodonaea triquetra*, *Polyscias sambucifolia* and *Acacia falcata*, and grass and herb species include *Themeda australis*, *Echinopogon caespitosus*, *Pseuderanthemum variable* and *Pratia purpurascens*. In the early 1840s Mrs Charles Meredith described the forest at Homebush and mentions native species including *Hardenbergia violacea*, *Kennedia rubicunda*, *Pandorea pandorana* and other species likely to be *Oxylobium scandens*, *Dillwynia juniperina*, *Daviesia ulicifolia*, *Platylobium formosum*, *Viola hederacea*, *Wahlenbergia* species, *Lissanthe strigosa* and *Leucopogon juniperinus* (Meredith 1844, quoted in Benson & Howell 1990a). Most of these species can still be found near Homebush Bay, where an important remnant of this vegetation survives in land used for storage of naval munitions (Clarke & Benson 1988; Kachka 1993), or in the Yaralla Bushland in nearby Concord Municipality (Benson 1983).

There is also a small yet important remnant of native vegetation on the banks of the Cooks River at the end of Third Avenue, Campsie (Benson 1992b). The vegetation has patches of scrub, grassland and some trees. Most of the vegetation is of plants native to the site, many of which are growing very vigorously. In particular, in some of the more open areas there is a rich flora of ground cover species in particular grasses and prostrate small shrubs, such as *Astroloma humifusum*, *Calotis cuneifolia* and *Goodenia hederacea*. There was a patch of the orchid *Microtis unifolia* and some very impressive clumps of *Xanthorrhoea media*. Populations of *Calotis cuneifolia*, *Hibbertia serpyllifolia* and *Oxylobium ilicifolium* are probably the only natural occurrences surviving in inner western Sydney. Patches of shrubs include *Kunzea ambigua*, *Leptospermum trinervium* and shrubby trees of *Syncarpia glomulifera*. One of the reasons for the vigorous native plant growth is that the natural soils are essentially unmodified and have

not received nutrients in run-off from other areas. In comparison, adjacent areas with dumped soil have a significant number of weeds. This vegetation is the only remnant of Turpentine–Ironbark Forest vegetation for many kilometres, and is virtually the only remnant of native vegetation on the banks of the Cooks River. The only other native vegetation in the Cooks River valley is along Wolli Creek, in Girrahween Park, associated with outcropping sandstone and having a different species composition from this remnant on shale at Campsie.

On the northern side of the Harbour remnants occur at Ryde in Wallumatta Nature Reserve (Benson 1984, see below) and Fagan Park at Galston (Benson & Keith 1984b) including a good local stand of *Eucalyptus acmenoides*, a species which reaches its southern distributional limit at the Parramatta River — a few trees survive in Maze Park, West Ryde.

Turpentine–Ironbark Forest vegetation extended onto the transition zone between the shale and the underlying Hawkesbury Sandstone, on soils formerly known as the Hammondville Association (Walker 1960). Some of this transitional vegetation still survives as narrow edgers to cleared land on private property and on the margins of sandstone bushland reserves in northern Sydney, where there are remnants of shale overlying sandstone, e.g. Pennant Hills Park, Lane Cove National Park (formerly State Recreation Area) (Clarke & Benson 1987) and Garigal National Park (formerly Davidson State Recreation Area), Ku-ring-gai Chase National Park (Thomas & Benson 1985a), Marra-marra National Park, and a number of Council parks. These patches are generally too small to map at the present scale. The vegetation of these areas differs from that on the deeper shale by including sandstone species. Structure is generally open-forest and tree species may be *Syncarpia glomulifera*, *Eucalyptus punctata*, *Eucalyptus paniculata* and *Eucalyptus globoidea*.

Protection of all small remnants of this shale-based flora is important since many of the smaller-growing species in particular are becoming rare, and many of the sites are in very vulnerable positions close to urban development and susceptible to weed invasion and nutrient-enriched run-off. Because shale areas are small and frequently on the margins of reserves, they may need particular and careful management.

Map unit 9sf

Duffys Forest

Open-forest: *Eucalyptus sieberi*–*Eucalyptus capitellata*–*Eucalyptus gummifera*–*Angophora costata*

On sandstone ridgetops in the Duffys Forest–Terrey Hills area are shale remnants from lenses within the Hawkesbury Sandstone (Herbert 1983), often with characteristic ironstone gravels, referred to as ‘laterite’ cappings. Soils are part of the Somersby Soil Landscape (Chapman & Murphy 1989), moderately deep yellow earths and deep red earths overlying laterite gravels and clays. A distinctive open-forest vegetation occurs on these.

At Duffys Forest, open-forest is 7–18 m high with a mid-dense canopy with trees of *Eucalyptus sieberi*, *Eucalyptus gummifera*, *Eucalyptus oblonga*, *Eucalyptus haemastoma* and *Angophora costata* (Benson 1974, 1979a; Thomas & Benson 1985a: community 10B). The understorey is of mid-dense shrubs often with emergent taller shrubs with a ground cover of low shrubs and monocots. Understorey species include *Telopea speciosissima*, *Xylomelum pyriforme*, *Ceratopetalum gummiferum*, *Banksia spinulosa*, *Persoonia levis*, *Micrantheum ericoides*, *Leptospermum trinervium*, *Pimelea linifolia*, *Acacia myrtifolia*, *Boronia pinnata* and *Cyathochaeta diandra*. Variation appears related to soil depth and type. Deeper soils carry more *Eucalyptus sieberi* with the occasional *Eucalyptus pilularis* and *Syncarpia glomulifera* and the understorey shrub *Bossiaea obcordata*, while thinner soils tend to support more sandstone woodland species. The central part of the original ‘Duffys Forest’ was cleared many years ago but Kartzoff (1969) reports that much blackbutt, *Eucalyptus pilularis*, was logged at Duffys Forest and that as a result of logging and burning, it is now extinct there, where it had been common 30 years before.

Thomas & Benson (1985a) also describe a slightly different community (community 10A) on low slope areas on shale-derived soils (possibly lateritic) and on deeper soils than the floristically similar *Eucalyptus sieberi* community. Structure is open-forest 0–17 m tall with a mid-dense canopy cover of trees of *Eucalyptus capitellata*, *Eucalyptus gummifera*, *Eucalyptus sieberi*, *Eucalyptus haemastoma*. The understorey has a sparse tall shrub layer, an open to mid-dense mid-height shrub



Figure 8. In the Leo Smith Reserve at Ramsgate there is an important remnant of Coastal Dune Forest, map unit 9t, with *Angophora costata* and a dense ground cover of Bracken and shrubs.

layer and an open to mid-dense ground cover of low shrubs, herbs and monocotyledons. Main species are *Ceratopetalum gummiferum*, *Persoonia levis*, *Acacia myrtifolia*, *Bossiaea obcordata*, *Banksia spinulosa*, *Lomatia silaifolia*, *Pultenaea elliptica*, *Micrantheum ericoides*, *Patersonia glabrata* and *Cyathochaeta diandra*. The shale influence on this community is distinctive and several species occur which are uncommon in the rest of the park (e.g. *Persoonia laurina*, *Pultenaea linophylla* form b. The threatened *Grevillea caleyi* occurs at the start of the Ryland Track. This community is very restricted in Ku-ring-gai Chase National Park. Similar vegetation also occurs at the junction of Forest Way and Mona Vale Rd, now part of Garigal National Park.

Also included in this map unit is open-forest with a very restricted distribution on remnant shale outcrops in the south of Brisbane Water National Park (mapped as community 4S, Benson & Fallding 1981). Trees here include *Eucalyptus gummiifera*, *Angophora costata*, *Eucalyptus globoidea*, *Eucalyptus umbra*, *Eucalyptus punctata* and *Syncarpia glomulifera*. The shrub understorey is dominated by members of the Fabaceae family, and ground cover species include *Poa affinis*, *Entolasia stricta* and species of *Lomandra*.

Map unit 9t

Coastal Dune Forest

Open-forest: *Eucalyptus botryoides*– *Eucalyptus pilularis*–*Angophora costata*

Coastal Dune Forest occurred on the quartz sand of the Holocene beach ridges that extend along the western shore of Botany Bay, and on the northern side of Broken Bay between Pearl Beach, Umina and Woy Woy (New South Wales Department of Mineral Resources 1983). It may also have occurred in sheltered sites on the 'marine' sands in Sydney's eastern suburbs, though most of this area appears to have had heath vegetation (Benson & Howell 1990a). Almost all has been destroyed by housing, with the exception of a small remnant on Botany Bay in the Leo Smith Reserve at Ramsgate, some low woodland with *Angophora costata* and *Eucalyptus botryoides* on the sheltered slopes of some dunes in Golf Courses at La Perouse, and a few remnants at Umina, too small to map.

Vegetation structure was originally open-forest to low woodland. *Eucalyptus botryoides*, *Eucalyptus pilularis* and *Angophora costata* appear to have been the main tree species, though *Angophora floribunda* is common in the Woy Woy occurrence.

Angophora floribunda, *Eucalyptus botryoides* and *Eucalyptus punctata* occur at Pearl Beach (Benson & Fallding (1981). The understorey was shrubby with such native species as *Banksia serrata*, *Elaeocarpus reticulatus*, *Hibbertia scandens*, *Leucopogon ericoides*, *Monotoca elliptica*, *Breynia oblongifolia*, *Glochidion ferdinandi* and *Pomax umbellata*. A species list for Leo Smith Reserve has been prepared by Benson & Keith (1985). This small area of open-forest at Ramsgate is the sole remnant of native sand vegetation of the beach ridge system (Outer Barrier) of western Botany Bay (nearby low-lying area has *Casuarina glauca* forest—Map unit 4a). It is different from the Eastern Suburbs *Banksia* Scrub of the transgressive dunes (map unit 21b), but has similarities to vegetation at Kurnell. Studies of intact vegetation on similar sand dune systems at Myall Lakes (Myerscough & Carolin 1986) demonstrate the complex nature of such vegetation systems.

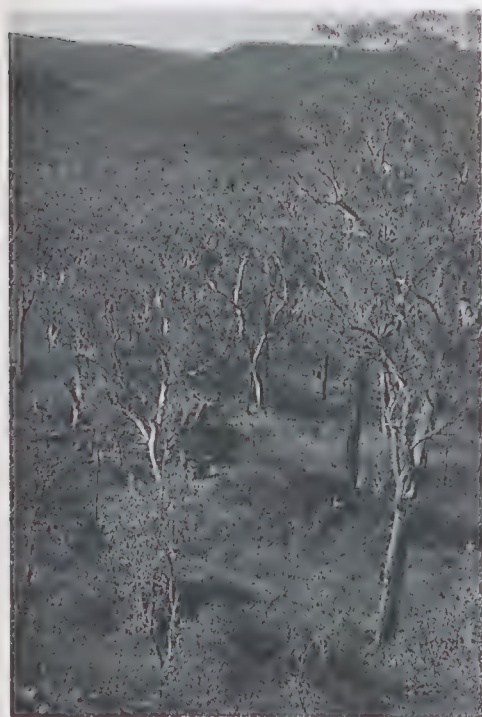


Figure 9. Some of the different habitats provided by the rugged sandstone topography are evident here in Ku-ring-gai Chase National Park — distant level ridgetops, exposed and sheltered hillsides and narrow valley floors each support different groupings of plant species.

Burges and Drover (1952) related vegetation patterns on the Holocene beach ridges between Umina and Woy Woy to increasing podzolisation and beachridge age (up to 4 000 years). Along the beach-front typical foredune colonisers were found, backed by a *Leptospermum laevigatum*–*Banksia integrifolia* thicket about 100 m wide. Isolated trees of *Eucalyptus botryoides* began to occur about 150 m from the beach and increased in number to form, with *Angophora floribunda*, a fairly open woodland on an area of iron podzol sands. Nearer to Woy Woy, on well-defined humus podzols, *Angophora floribunda* was replaced by *Angophora costata*. The swampy areas between the sand ridges had a range of vegetation from open water with *Typha*, to *Melaleuca quinquenervia* woodland. Remnant trees of *Angophora floribunda*, *Angophora costata*, *Eucalyptus pilularis*, *Glochidion ferdinandii* and a few conspicuous *Macrozamia communis* along the road verges around Ettalong and Umina are generally all that remains of this vegetation.

Sydney Sandstone Complex (map units 10ag and 10ar)

This widespread vegetation complex occupies extensive areas of the Hawkesbury Sandstone plateaus and associated gullies. Depending on topographic position and aspect, there is considerable local variation in floristics and structure. Thomas and Benson (1985a), mapped 12 units for Hawkesbury Sandstone in Ku-ring-gai Chase National Park. Two broad sub-units have been recognised. These are a moist forest type, generally associated with sheltered hillsides and moist gullies (map unit 10ag), and a dry woodland type, generally associated with dry plateaus and ridges (map unit 10ar). These units have been used on the Katoomba, Wallerawang and Penrith sheets but not on the Gosford and Lake Macquarie map sheet (Benson 1986a), where a composite Hawkesbury Sandstone unit (map unit 10a) was used.

Sydney Sandstone Complex (map units 10ag and 10ar) ranges from tall open-forest to low woodland and open-scrub. It corresponds with part of the Mixed *Eucalyptus* Forest Association of Pidgeon (1937, 1938). In the map units described in this paper, Map Unit 10ag is essentially Pidgeon's High Forest, Map Unit 10ar includes scrub, tree-scrub, low scrub-forest and tall scrub-forest, and Map Unit 21g includes extensive areas



Figure 10. This open-forest in Pennant Hills Park, map unit 10ag(i), is typical of the vegetation on sheltered sandstone slopes in many of Sydney's bushland reserves.

of scrub, as well as sedge and shrub swamp. In terms of the floristic survey of Ku-ring-gai Chase by Outhred et al. (1985), Map Unit 10ag includes many of the M (particularly M4–M7), MT, and R series, while map unit 10ar covers the S, L and M (M1–M3) series.

Map unit 10ag

Sydney Sandstone Gully Forest

Sydney Sandstone Gully Forest has a widespread geographic distribution. It is found on the Hawkesbury Sandstone topography of the coast, Hornsby Plateau, lower Blue Mountains and Woronora Plateau. Map unit 10ag, open-forest to woodland, is generally confined to gullies and sheltered hillsides, particularly on southern to eastern aspects. Soils are shallow lithosols and siliceous sands, yellow earths and yellow podzolics (Hawkesbury Soil Landscape of Chapman & Murphy 1989), with deeper podzolic soils enriched by downwash material on lower slopes and in narrow valleys. Average height of the trees is 25 m, though varying from 18–30 m. Three sub-units are recognised.

i) Open-forest/woodland: *Eucalyptus piperita*–*Angophora costata*–*Eucalyptus pilularis*

The main trees are *Eucalyptus piperita*, *Angophora costata* and *Eucalyptus gummiifera*. *Allocasuarina*

littoralis is a common smaller tree. The understorey is dominated by a variety of shrubs, 0.5–2 m high, the main families being Proteaceae, Fabaceae and Myrtaceae. Pidgeon (1938) and Thomas and Benson (1985a) both list the following as frequent species: *Persoonia pinifolia*, *Acacia terminalis*, *Pultenaea daphnoides* and *Dodonaea triquetra*. There is considerable local variation in this community. For example localised occurrences of podzols on the Hornsby Plateau (Buchanan & Humphreys 1980), are characterised by the inclusion of a particular group of species, *Ceratopetalum gummiifera*, *Xylomelum pyriforme*, *Xanthorrhoea arborea*, *Ricinus carpos pinifolius* and *Gompholobium latifolium*.

Woodland of the more exposed parts of hillsides grades into open-forest as conditions become more sheltered, forming the vegetation characteristic of extensive tracts of sheltered sandstone slopes and gullies.

ii) Tall open-forest: *Eucalyptus pilularis*–*Syncarpia glomulifera*

Tall open-forest with trees over 30 m tall is found on the lower slopes of sandstone gullies in the Berowra Creek area, and on lower slopes where there is a localised enrichment from downwashed shale soils such as in the Lane Cove Valley. The

main trees are *Eucalyptus pilularis* and *Syncarpia glomulifera* but also occurring are trees of *Eucalyptus piperita* and *Angophora costata* generally associated with adjacent open-forest. *Allocasuarina torulosa* is a common smaller tree in the understorey

iii) Closed-forest: *Ceratopetalum apetalum*–*Tristaniopsis laurina*

This is the distinctive riparian flora occurring in narrow bands along perennial creeks. It may be locally of closed-forest structure, but is most commonly scrub, spaced out amongst boulders of the sandstone banks. It is generally an understorey to open-forest of *Eucalyptus piperita* or *Angophora costata*. Characteristic species are *Tristaniopsis laurina*, *Callicoma serratifolia*, *Lomatia myricoides*, *Leptospermum polygalifolium*, and *Austromyrtus tenuifolia*, with *Ceratopetalum apetalum* occurring in more favourable sites. The rare *Leptospermum deanei* is found only along Middle Harbour Creek and the upper Lane Cove River. In sheltered gullies that receive downwash from ridges with Wianamatta Shale there may be tall open-forest with *Eucalyptus saligna*, and occasional rainforest species such as *Schizomeria ovata*, with ferns in the understorey.

Vegetation on soils on small volcanic intrusions are included in this map unit. For example, open-forest with *Eucalyptus agglomerata* and *Angophora floribunda* at Campbells Crater, and open-forest with *Eucalyptus paniculata* and *Eucalyptus umbra* on a dyke at West Head, both within Ku-ring-gai Chase National Park. Such sites have characteristic understorey species related to the generally more clayey and higher nutrient status of the volcanic soils (Thomas & Benson 1985a; Sanders 1983).

Map unit 10ar

Sydney Sandstone Ridgertop Woodland

Sandstone Ridgertop Woodland is found on the more exposed ridges and plateau tops with shallower soils interrupted by outcrops of rock. Soils are shallow lithosols and earthy sands, yellow earths and yellow podzolics (Faulconbridge, Lucas Heights, Hawkesbury and Lambert Soil Landscapes of Chapman & Murphy 1989). There may be an average depth of 5–10 cm in some habitats but tree roots penetrate the deeper pockets of soil amongst the underlying rocks (Pidgeon 1938).



Figure 11. Low open woodland, map unit 10ar(ii), with *Angophora bakeri* and *Eucalyptus haemastoma* in Muogamarra Nature Reserve.

i) Woodland/Low woodland: *Eucalyptus gummifera*–*Eucalyptus haemastoma*–*Eucalyptus sparsifolia*–*Eucalyptus racemosa*

This is structurally very variable and includes areas of woodland, open-woodland, low woodland and low open-woodland, depending on local aspect, soil and drainage conditions, as well as the time since the last fire. Characteristic tree species are *Eucalyptus gummifera*, *Eucalyptus sparsifolia*, *Eucalyptus haemastoma* and *Eucalyptus racemosa*, sometimes with some intergradation between the latter two scribbly gum species. *Eucalyptus piperita* and *Angophora costata* may also occur. Localised patches of mallee eucalypts, *Eucalyptus luehmanniana*, *Eucalyptus obtusiflora*, *Eucalyptus camfieldii* and *Eucalyptus multicaulis*, may be responding to locally moister sites, or shallow rock platforms. *Eucalyptus capitellata* occurs on some more clayey ridges in the Terrey Hills area.

These dry, exposed communities have a rich sclerophyllous shrubby understorey, particularly with species of Proteaceae, Fabaceae, Epacridaceae and Myrtaceae. Common shrubs in Ku-ring-gai Chase National Park include species of *Pultenaea*, *Isopogon*, *Hibbertia*, *Hakea*, *Banksia*, *Boronia*, *Leucopogon*, *Grevillea*, *Gompholobium* and *Tetratheca*, as well as *Dillwynia retorta*, *Phyllota phyllicoides*, *Leptospermum trinervium*, *Petrophile pulchella* and *Platysace linearifolia* (Thomas & Benson 1985a).

ii) Woodland/low woodland: *Eucalyptus eximia*–*Eucalyptus gummifera*–*Angophora bakeri*

This vegetation is found on dry hillsides and ridges in the north-west of the map sheet area, west of Berowra Creek, and is particularly widespread in Marramorra National Park. Rainfall is generally less than 1000 mm p.a., in contrast to the higher-rainfall (1000–1200 mm) country of Ku-ring-gai Chase and Brisbane Water National Parks. Characteristic trees include *Eucalyptus eximia* and *Angophora bakeri*, as well as the more widespread *Eucalyptus gummifera* and *Angophora costata*. Similar vegetation extends west to the lower Blue Mountains (Benson 1992a) and north into the MacDonal (Sanders et al. 1988) and Colo River areas.

iii) Open-scrub: *Banksia ericifolia*–*Hakea teretifolia*

In sites with shallow poorly-drained soil, patches of open-scrub with tall shrubs of *Banksia ericifolia* and *Hakea teretifolia* occur. Within the ridgetop

woodland small patches of Coastal Sandstone Heath (Map Unit 21g) may occur, in particular coastal heath with *Banksia ericifolia* and *Darwinia fascicularis*, Open-heath with *Allocasuarina* and *Banksia ericifolia*, Rocky outcrop heath with *Baeckea diosmifolia* and *Baeckea brevifolia*, Wet heath with *Hakea teretifolia* and *Banksia oblongifolia*, and Open-scrub with *Angophora hispida*.

As mentioned earlier, floristic differences between gully forest and ridge woodland can be distinguished in Outhred's floristic analysis of Ku-ring-gai Chase vegetation, though there is considerable overlapping of species distributions. However, differences between the scrub or shrub-dominated vegetation and the taller woodland/forest vegetation are perhaps more marked. In particular, many species are essentially confined to the scrub vegetation or very open low tree vegetation, e.g. *Allocasuarina distyla*, *Phebalium squamulosum*, *Banksia oblongifolia*, *Kunzea capitata*, *Mirbelia rubrifolia*, *Stylidium lineare*, *Epacris microphylla*, and *Grevillea speciosa*. In contrast, very few species (e.g. *Micrantheum ericoides*), are essentially confined to the woodland, which is mainly made up of species that occur in both woodland and scrub, or woodland and forest. The woodland appears to be an ecotone between the heath and the forest.

Vegetation surveys of major Sydney sandstone areas include Brisbane Water National Park (Benson & Fallding 1981), Boudi National Park (McRae 1990), Muogamarra Nature Reserve (Thomas & Benson 1985b), Ku-ring-gai Chase National Park (Thomas & Benson 1985a, Outhred et al. 1985, Rose 1982), Berowra Valley Bushland Park (Smith & Smith 1990), Pennant Hills Park (Beecroft–Cheltenham Civic Trust 1976), Lane Cove River State Recreation Area (Clarke & Benson 1987), Garigal National Park (McDougall & Conroy 1988–90, Sheringham & Sanders 1993) and *Angophora* Reserve and Hudson Park (Smith & Smith 1993). Brief reports and species lists are available for some of the islands of Broken Bay — Lion Island (Benson 1981, McDougall 1989), Spectacle Island (Webb 1981), Milson Island (Cleland 1914), Bar Island (Benson 1984) and Big Bay Island (Benson et al. 1989). Many of these lists have been included in Table 3.

Vegetation descriptions and/or species lists have been compiled for many other areas including the



Figure 12. Coastal heath with *Allocasuarina distyla* at Bouddi National Park, map unit 21a(i), grades into woodland where there is shelter from onshore winds.

following ('V' indicates vegetation description included, 'F' indicates floristic list, 'M' indicates map): Elouera Bushland Reserve, Coveny (h) F, Benson (1980b) V; Katandra Sanctuary, Mona Vale, Coveny (l) F; Cheltenham, Coveny (b) F; Deep Creek, Narrabeen, McKern (1962) F, Coveny (f) F, Benson (1979a) V; Dee Why Lagoon, Coveny (g) F; Cumberland State Forest, Coveny (d) F; Lake Parramatta Reserve, Workers' Education Association Plant Ecology Group (1959) F, Coveny (m) F; Mowbray Park, Buchanan (1979a) VFM; Bantry Bay, Upper Middle Harbour Conservation Committee (1974) VFM; Manly Reservoir, Coveny (o) F; Vineyard Creek, Telopea, Benson (1980c) VF; Rawson Park, Mosman, Bradley & Bradley (1966–74) F, Benson (1975) VF; Garden Island, Rodd & Benson (1977) F; Outer Domain, Maiden (1902) also in Wilson (1985); Vacluse, Holland (1980); Wolli Creek–Undercliffe–Bexley North, Benson (1978b) VF; Robinson (1986, 1987); Long Bay, Benson 1978a VF; Glebe Gully, Randwick, Coveny (j) F; La Perouse, Armstrong et al. (1976) VF.

Map unit 21a

Coastal Clay Heath

Coastal Clay Heath vegetation occurs on coastal headlands on shales and sandstones of the

Narrabeen Group, mostly interbedded laminite and shale with quartz to lithic quartz sandstone. These are found along the coastline in Bouddi National Park (McRae 1990) and along the Warringah Peninsula between Long Reef and Barrenjoey. Further north Coastal Clay Heath is found at Norah Head and from Munmorah State Recreation Area to Catherine Hill Bay (Benson 1986a, Adam, Stricker et al. 1989). Vegetation here is low and scrubby, both because of the low nutrient status of its soils, and because it is exposed to winds from the ocean which restrict tree growth. Soils are variable, with lithosols, siliceous sands and yellow podzolics on the sandstone, and brown and red podzolics on the shale strata (Chapman & Murphy 1989). Heath vegetation occurs on the more sandy soils, while those with more clay tend to support grassy vegetation.

i) Open-heath: *Allocasuarina distyla*

Heath vegetation at Bouddi may range from open-heath to closed-heath 1.5m high and with up to 95% canopy cover depending on time since fire (McRae 1990). Similar vegetation occurs on Barrenjoey Head. The most characteristic canopy species is *Allocasuarina distyla*; other heath species include *Hakea teretifolia*, *Banksia ericifolia*,

Lasiopetalum ferrugineum and *Platysace linearifolia*. The ground stratum is poorly developed, including *Lomandra longifolia*, or absent. Fire kills the *Allocasuarina*, which relies on seed for reestablishment, and for a number of years its seedlings cannot attain dominance over those of other species or over species relying on lignotubers for regrowth. During this phase the local species richness is increased and abundant species include *Hakea teretifolia*, *Banksia ericifolia*, *Isopogon anemonifolius*, *Isopogon anethifolius*, *Woollsia pungens*,

Actinotus helianthi, *Cyathochaeta diandra* and *Themeda australis* (McRae 1990).

Allocasuarina distyla open-heath appears to be part of the *Banksia serrata*–*Allocasuarina distyla* community of Adam, Stricker et al. (1989) who comment that in overall diversity and species composition, stands on Hawkesbury Sandstone in the Sydney region and on Permian sandstone around Jervis Bay are very similar. It is also similar to their *Banksia ericifolia*–*Westringia fruticosa* community.

ii) Grassland: *Themeda australis*

Grassland dominated by *Themeda australis* occurs on exposed sites below coastal cliffs at Bouddi (McRae 1990) and on the Warringah Peninsula. It varies in height from 0.1 to 1 m with about 70% cover. *Themeda australis* is the main species, but there may also be a mixture of severely windswept shrubs such as *Westringia fruticosa*, *Banksia integrifolia* and *Baeckea imbricata*, smaller plants such as *Isolepis nodosus*, *Apium prostratum* and *Carpobrotus glaucescens* and the ferns, *Gleichenia rupestris* and the introduced *Cyrtomium falcatum*. *Themeda australis* grassland generally occurs on the most fertile headland soils possibly reflecting the long history of use and disturbance to which such sites have been subject (Adam, Stricker et al. 1989).

Map Unit 21b

Coastal Dune Heath

Coastal Dune Heath is found sporadically along the New South Wales coast. Major occurrences include Myall Lakes (Myerscough & Carolin 1986). On the Sydney map sheet Coastal Dune Heath is found on Mourawaring and Bombi Moors in Bouddi National Park (McRae 1990), at North Head, and in the Eastern Suburbs of Sydney. *Banksia aemula* open-heath is found on disjunct patches of highly leached, perched Pleistocene dune sand. The other community occurs on 'marine' sands of Holocene age. Coastal Dune Heath vegetation is often found associated with low woodland of *Angophora costata* and *Eucalyptus botryoides* on the sheltered slopes of steeper dunes (see Map unit 9t Coastal Dune Forest).



Figure 13. Grassland with *Themeda australis*, map unit 21a(ii), is characteristic of exposed coastal headlands of the Narrabeen Group shales and sandstone.

i. Open-heath: *Banksia aemula*

Banksia aemula open-heath is found on disjunct patches of highly leached, perched Pleistocene dune sand, on the Bombi and Mourawaring Moors in Bouddi National Park, on North Head and at La Perouse. Such sites are normally away from the immediate coastal environment and receive little salt-spray, but are on very low nutrient-status soils. This vegetation is discussed by Siddiqi et al. (1972) at Bouddi as dry *Banksia serratifolia* [= *aemula*] heath and by Adam, Stricker et al. (1989) as the *Banksia aemula*–*Hypolaena fastigiata* community.

At Bouddi, the shrub layer is up to 1.5 m high, with 20% canopy cover, and often merges with the low ground stratum, with 80% cover, dominated by graminoids (McRae 1990). The dominant shrub is *Banksia aemula* and common shrubs include *Allocasuarina distyla*, *Lambertia formosa*, *Platysace linearifolia*, *Isopogon anemonifolius*, *Persoonia lanceolata*, *Leptospermum polygalifolium* and low-growing *Eucalyptus umbra* and *Angophora costata*. Common understorey species include *Hypolaena fastigiata*, *Bossiaea ensata*, *Woolisia pungens* and *Lepidosperma* species. On the edges of the dunes a low open-woodland, 3 to 8 m high, dominated by *Angophora costata*, *Eucalyptus umbra* and *Allocasuarina distyla*, develops.

Pleistocene sand at North Head occupies the central part of the plateau but has been largely cleared of vegetation by the Army. A fringe of vegetation remains, some of which is in Sydney Harbour National Park. Most of this has been protected from fire for at least 30 years and now forms a dense scrub 8 m high dominated by the taller-growing *Leptospermum laevigatum* (Horton 1986). There are smaller shrubs of *Banksia aemula*, *Kunzea ambigua* and *Leptospermum*, many of which are now senescent or dying. Invasion of heathland by *Leptospermum laevigatum* in the absence of fire has been reported by Burrell (1981). An interesting aspect of the vegetation at North Head is the deterioration and death of individuals of the species *Eucalyptus camfieldii*, evidently in response to the lack of fire.

Small remnants of *Banksia aemula* open-heath, described as part of the Eastern Suburbs Banksia Scrub (Benson & Howell 1990a) occur at La Perouse, near Jennifer Street. This is the southern limit of distribution of *Banksia aemula* open-heath.



Figure 14. A small patch of the Eastern Suburbs Banksia Scrub, map unit 21b(ii), survives at Jennifer St, La Perouse. The tall flowering spikes of *Xanthorrhoea resinosa* are conspicuous, particularly after fire.

Common shrub species here are *Banksia aemula*, *Monotoca elliptica*, *Eriostemon australasius*, *Ricinocarpus pinifolius* and *Xanthorrhoea resinosa*. There are many other species here and protection of the area is an important ongoing conservation issue. It has been burned frequently.

ii. Open-scrub: *Monotoca elliptica*–*Banksia integrifolia*–*Leptospermum laevigatum*

This occurs on 'marine' sands of Holocene age and occasionally on in situ weathering of Hawkesbury Sandstone. Floristically not very diverse, *Monotoca elliptica* is the only constant (Adam, Stricker et al. 1989), but *Banksia integrifolia*, *Leptospermum laevigatum*, *Melaleuca armillaris*, *Pimelea linifolia* and *Acacia sophorae* are widespread. The shrub layer is frequently wind-pruned, but in sheltered locations *Monotoca elliptica* and *Leptospermum laevigatum* may be 3–4 m tall.

Map Unit 21g

Coastal Sandstone Heath

James Atkinson provided this excellent description of coastal heath in 1826. 'The barren scrubs almost every where border the sea coast, and extend to various distances inland; in some places two or three miles; in others, lands of a better description approach close to the water's edge. The soil in these scrubs is either sandstone rock or sterile sand or gravel, covered, however, with a



Figure 15. Coastal scrub with *Banksia integrifolia*, map unit 21b(ii), near Pearl Beach on the northern side of Broken Bay.

profusion of beautiful shrubs and bushes, producing the most elegant flowers, and affording a constant succession throughout the whole year, but most abundant in winter and spring; the shrubs and plants growing in these places furnish the Colonists with materials for brooms, but produce little else that can be converted to any useful purpose. — The grass tree, with its lofty flower stalk, is a conspicuous object in these wastes; of the hard and woody but light stalk of this plant the natives make the shaft of their spears, and shooting or fish gigs. Very few trees grow in these places, except a few stunted (sic) gum trees, in situations sheltered from the sea winds. Much honey might probably be collected from these scrubs, were bees plentiful in the Colony, and some small profit may possibly be thus made of them hereafter; but with this exception, they scarcely seem susceptible of any improvement'.

Coastal Sandstone Heath is found on Hawkesbury Sandstone headlands along the coast from Long Reef to La Perouse, and on nearby sandstone plateaus and ridges, particularly in the Deep Creek catchment and the Lambert Peninsula in Ku-ring-gai Chase National Park. Habitats include broad ridges, gently to moderately inclined slopes, wide rock benches with low broken scarps, small hanging

valleys and areas of poor drainage. Soils are shallow, discontinuous earthy sands and yellow earths, siliceous sands, lithosols, leached sands, grey earths and gleyed podzolics (Lambert and Hawkesbury Soil Landscapes of Chapman & Murphy 1989).

Vegetation structure is variable, ranging through open-heath, shrubland, mallee, and sedgeland. Structure is influenced by fire frequency and the time since the last fire. Particularly important are the large, relatively quick-growing, but fire-sensitive (i.e. killed by fire) species (e.g. *Banksia ericifolia*, *Hakea teretifolia*, *Allocasuarina distyla*, *Petrophile pulchella*) that may readily predominate in a range of habitats under particular fire regimes. The interaction between these species and the generally slower-growing, more long-lived resprouter species (e.g. *Banksia oblongifolia*, *Angophora hispida*, *Lambertia formosa*) is an important consequence of the particular fire regimes in an area, with subsequent effects on vegetation structure and floristics. This is a potential area for future research. The other major factor in heath composition is soil moisture, and different communities are recognisable across the full range of drainage conditions.

Broad communities are recognised here, but there is considerable overlap and variation depending

on the scale of the study. Small areas of this vegetation have also been mapped in unit 10ar.

i) Shoreline shrubland

Shrubland: *Baeckea imbricata*

On coastal sandstone headlands low shrubland of *Baeckea imbricata* frequently provides the most seaward zone of continuous vegetation. It is rarely more than 20 m wide, though *Baeckea* can be found as a component of communities considerably further inland (Adam, Stricker et al. 1989). The low-growing shrub, *Baeckea imbricata*, predominates in this community — *Westringia fruticosa* is frequent, but not abundant. High inputs of salt-spray are experienced and saltmarsh species occur — *Sporobolus virginicus*, *Samolus repens*, *Zoysia macrantha*. At more inland localities *Baeckea imbricata* dominates communities in wet hollows, where the community is a form of wet heath. Associated species include *Epacris obtusifolia*, *Callistemon citrinus* and *Sprengelia incarnata*. Good examples occur at North Head (Horton 1986), Long Bay and La Perouse. A detailed account of seaciff and headland vegetation is given in Adam, Stricker et al. (1989).

ii) Coastal heath

Open-heath/closed-scrub: *Banksia ericifolia*–*Darwinia fascicularis*

On the landward side of the *Baeckea* low shrubland, Adam, Stricker et al. (1989) describe a *Banksia ericifolia*–*Westringia fruticosa* community and then a more extensive (up to 1 km inland) *Banksia ericifolia*–*Darwinia fascicularis* closed-heath community. Frequent species include *Allocasuarina distyla*, *Hakea teretifolia*, *Melaleuca nodosa*, *Dillwynia floribunda*, *Lasiopetalum ferrugineum*, *Baeckea imbricata*, *Leucopogon microphyllus*, *Lepidosperma viscidum*, *Eriostemon buxifolius* and *Epacris microphylla*. Drainage is an important factor in determining the presence of particular species, Clemens and Franklin (1980) recognising differences in heath vegetation on North Head related to soil depth and drainage.

Banksia ericifolia–*Darwinia fascicularis* closed-heath occurs extensively at North Head (Clemens & Franklin 1980, Horton 1986), Long Bay and La Perouse, and is widespread on Hawkesbury Sandstone on the Central Coast of NSW as well as on soils from Permian Sandstone near Jervis Bay.



Figure 16. Coastal heath on sandstone rock platforms at Long Bay (map unit 21g(ii)).

iii) Open-heath/closed scrub: *Allocasuarina distyla*–*Banksia ericifolia*

This is similar to the previous community but occurs away from the immediate coastal influence and is widespread in Brisbane Water, Ku-ring-gai Chase and Garigal National Parks. It ranges from closed-scrub up to 4 m high to open-heath, with species such as *Banksia ericifolia*, *Allocasuarina distyla*, *Leptospermum trinervium*, *Phebalium squamulosum*, *Phyllota phyllicoides*, *Angophora hispida* and *Pultenaea elliptica*.

iv) Rocky outcrop heath

Open-heath: *Baeckea diosmifolia*–*Baeckea brevifolia*

Vegetation with a dense shrub cover to 1.5 m high among scattered, stunted emergent trees, occurs on broad, flat sandstone ridges with extensive rock outcrops, sometimes with occasional dense bonsai-like mats of *Baeckea* species (Sheringham & Sanders 1993). Shrubs include *Baeckea diosmifolia*, *Baeckea brevifolia*, *Allocasuarina distyla*, *Darwinia fascicularis*, *Kunzea capitata* and *Dillwynia sericea*. Such vegetation occurs commonly in Brisbane Water, Ku-ring-gai Chase and Garigal National Parks and in smaller parks in the Warringah area, for example at Bantry Bay (Upper Middle Harbour Conservation Committee 1974), and Manly-Warringah War Memorial Park (Benson 1981b).

v) Wet heath

Closed heath: *Hakea teretifolia*–*Banksia oblongifolia*

Closed-heath to 2 m high dominated by shrubs including *Banksia oblongifolia*, *Banksia ericifolia*, *Hakea teretifolia*, *Dillwynia floribunda*, *Epacris obtusifolia*, *Leptospermum squarrosus*, *Baeckea imbricata* and *Sprengelia incarnata* occurs on poorly-drained sandstone.

vi) Sedgeland/shrubland: *Banksia robur*–*Viminaria juncea*–*Gymnoschoenus sphaerocephalus*

Swamps form where drainage is permanently impeded. In the wettest areas these may be sedge swamps dominated by species of Cyperaceae and Restionaceae, or in drier sites, shrub swamps (Pidgeon 1938). Buchanan (1980) describes four distinct but intergrading swamp types for the Lambert Peninsula in Ku-ring-gai Chase National Park. Keith and Myerscough (1993) provide an excellent study of similar swamp vegetation on the Woronora Plateau.

vii) Open-scrub: *Angophora hispida*

Small patches of open-scrub with *Angophora hispida* occur in Marramarra National Park, either on ridges or associated with rock platforms. Characteristic species of these sites include *Calytrix tetragona*, *Dillwynia floribunda*, *Grevillea buxifolia*, *Petrophile pulchella* and *Platysace*



Figure 17. Extensive rocky outcrops with pockets of heath, map unit 21g(iv), occur in Brisbane Water National Park.

ericoides. This vegetation probably represents a low-rainfall variant (annual rainfall about 800 mm) of the more coastal sandstone heaths (annual rainfall 1000–1200 mm). Heath is rare in low rainfall sandstone areas where it is replaced by woodland, indicating the importance of high moisture and poor drainage in preventing tree growth in heath areas.

viii) Shrubland (mallee): *Eucalyptus luehmanniana*

Small localised occurrences of *Eucalyptus luehmanniana* mallee shrubland or woodland occur in Garigal and Ku-ring-gai National Parks. These occur on sheltered upper to mid slopes on south-westerly to south-easterly aspects where drainage is poor and often associated with patches of wet heath (Sheringham & Sanders 1993).

Map Unit 27a

Coastal Swamp Forest Complex

i) Open-forest: *Eucalyptus botryoides*–*Eucalyptus robusta*

This occurs on poorly-drained sites in the Pittwater area, such as the Warriewood wetlands, but has been extensively disturbed, and very little remains.

ii) Open-forest: *Livistona australis*

Localised patches of *Livistona australis*, Cabbage Palm, occur in open-forest along the Warringah Peninsula from Palm Beach to Avalon, and along sections of Deep and Middle Creeks, particularly near Wakehurst Parkway. It also formerly occurred along the southern foreshores of Port Jackson in Sydney's eastern suburbs between Woolloomooloo and Rose Bay, but no naturally occurring palms are known to survive there now.

iii) Scrub: *Melaleuca linariifolia*–*Melaleuca styphelioides*

Paperbark swamp 5–18 m high with mid-dense to sparse cover of trees of *Melaleuca linariifolia* and *Melaleuca styphelioides*, small trees of *Callicoma serratifolia* and *Acacia longifolia* and sedges and ferns, *Gahnia clarkei*, *Gahnia sieberiana* and *Blechnum camfieldii* are found on floodplain alluvium along Deep Creek on better-drained areas surrounding herbland (Sheringham & Sanders 1993).



Figure 18. Remnants of the Botany Swamps at Eastlakes, map unit 28c(i) — sedgeland and open water provide important habitat for waterbirds and other wildlife.

iv) Reedland: *Phragmites australis*–*Typha orientalis*

Patches of reedland up to 3 m high, dominated by mainly *Phragmites australis* or *Typha orientalis*, grow on alluvial soils in estuaries and creeks in areas inundated with water for long periods and often brackish.

v) Herbland: *Persicaria strigosa*–*Blechnum camfieldii*–*Triglochin procera*–*Baumea juncea*

Waterlogged soil on alluvial floodplain of Deep and Middle Creeks has dense cover of herbs and sedges up to 2 m high. Ground species include *Persicaria strigosa*, *Blechnum camfieldii*, *Triglochin procera*, *Baumea juncea*, *Hypolepis muelleri*, *Viola hederacea*, *Isachne globosa* and *Villarsia exaltata*. Emergent shrubs include *Melaleuca styphelioides*, *Melaleuca linariifolia*, *Acacia longifolia* and *Leptospermum juniperinum* (Sheringham & Sanders 1993).

Map Unit 28c

Coastal Freshwater Swamp

This unit occurs in coastal freshwater swamp habitats, most of which have now been reclaimed, dammed or badly disturbed. They were particularly abundant on the sand deposits of the Eastern Suburbs (see Benson & Howell 1990a), with smaller swamps in the Woy Woy–Umina area. The main surviving examples are the Lachlan Swamp in Centennial Park and the Botany Swamps at Eastlakes and Botany.



Figure 19. Old paperbarks, *Melaleuca quinquenervia*, with a ferny understorey in the Lachlan Swamp Reserve in Centennial Park (map unit 28c(ii)).

i) Open-sedgeland: *Eleocharis sphacelata*–*Baumea juncea*–*Persicaria decipiens*

Damming of the Botany Swamps last century provided one of Sydney's water supplies. Today there are lakes with open water and patches of tall emergent sedges, particularly *Eleocharis sphacelata*.

Areas of native vegetation are in the Millstream section of the Botany Swamps adjacent to Wentworth Avenue. Here, with patches of low woodland of *Melaleuca quinquenervia*, is sedgeland with *Baumea articulata*, *Baumea rubiginosa*, *Baumea juncea* and *Gahnia sieberiana*. There are also herbaceous species *Persicaria decipiens*, *Persicaria strigosa*, *Philydrum lanuginosum* and *Ludwigia peploides* subsp. *montevideensis*, and shrubs of *Leptospermum juniperinum*, *Callistemon citrinus* and *Viminaria juncea*. Unfortunately, as a result of disturbance, there is a considerable amount of exotic weed, in particular the shrub *Ludwigia peruviana*. The Water Board is taking steps to alleviate this problem and to rehabilitate the Wetlands.

ii) Low forest: *Melaleuca quinquenervia*

At the Lachlan Swamp Reserve in Centennial Park is a dense forest of *Melaleuca quinquenervia* with fern-banks of *Gleichenia dicarpa* and *Hypolepis muelleri*, and *Gahnia sieberiana*, still much the same as when described by Hamilton in 1919. 'These ferns [*Gleichenia dicarpa* and *Hypolepis muelleri*] may be observed engaged in such a competition in a peaty swamp in Centennial Park'. Extensive *Melaleuca* forest also occurred across the peaty flats behind Rose Bay (Hamilton 1919), whereas only a few individual trees survive today.

Major conservation areas

The rugged and inhospitable nature of the sandstone environments restrict development. As a result, many areas of natural vegetation remain, giving bushland surroundings to many Sydney suburbs. The importance of this urban bushland is now appreciated and a body of knowledge concerned with its management and protection is being developed by the various land management organisations together with input from research and teaching institutions and community groups.

A brief description of the vegetation of the major national parks and other conservation areas is given below. Plant species lists for most of these areas are compiled in Table 4, but it should be noted that the information available for different areas varies considerably. Many of the smaller urban bushland areas are described in Benson and Howell (1990a).

Angophora Reserve and Hudson Park

This is a reserve of about 18 ha at Avalon on Hawkesbury Sandstone capping and underlying Narrabeen Group (Newport Formation) interbedded shales and sand-

stones. Vegetation is *Angophora costata*–*Eucalyptus gummifera* woodland (about 8 ha), with a small area of fern swamp, *Gleichenia dicarpa* and sedge swamp, with *Lepyrrodia scariosa* and *Epacris microphylla* on the Hawkesbury Sandstone; *Eucalyptus maculata* open-forest (about 8 ha) and a small area (about 0.5 ha) of *Livistona australis* palm stands on the Narrabeen Group soils (Smith & Smith 1993). A total of 293 vascular plant species have been recorded (227 native and 66 exotic), and the reserve includes the only known site around Sydney for the rare *Arthrochilus prolixus* (Smith & Smith 1993).

Barrenjoey Head

Barrenjoey Head at the southern entrance to Broken Bay is an isolated headland with a capping of Hawkesbury Sandstone overlying Narrabeen Group shales and sandstones. It is connected to the mainland by the thin strip of sand of Palm Beach. Woodland with *Eucalyptus botryoides* and *Banksia integrifolia* covers at least half of the headland extending from shore to ridgetop, particularly on the western half. Shrubs commonly found in the woodland understorey are *Pultenaea ferruginea* var. *deanei*, *Pultenaea daphnoides*, *Oxylobium ilicifolium* and *Jacksonia scoparia*.

Pockets of rainforest with *Acmena smithii* occur on shale soils in sheltered southerly aspects. Other species include *Backhousia myrtifolia*, *Syzigium oleosum*, *Pararchidendron pruinosum*, *Rhodomyrtus psidioides* (southern limit), *Diospyros australis*, *Guioa semiglaucula*, *Cassine australis* var. *australis* and *Marsdenia rostrata*. *Tristaniopsis collina* is frequent in sheltered places and in the woodland, with occasional occurrences in heathland sheltered by large sandstone outcrops.

Allocasuarina distyla heathland occurs on clay soils on the upper parts of the headland and on the eastern end where it is more stunted. Common shrubs include *Hakea gibbosa*, *Acacia myrtifolia*, *Banksia ericifolia*, *Leptospermum trinervium*, *Lasiopetalum*



Figures 20 & 21. Conservation reserves have various forms of access that allow visitors to explore and experience the Sydney bush.

macrophyllum, *Isopogon anethifolius* and *Kunzea ambigua*. The small shrub *Mirbelia rubiifolia* and the sedge *Schoenus melanostachys* are very common in the lower stratum. *Leptospermum laevigatum* shrubland occurs on the lower southern slopes.

Berowra Valley Bushland Park

Berowra Valley Bushland Park (3880 ha in area) includes bushland along Berowra Creek and its tributaries from Pennant Hills to Berowra Waters. It was established as a reserve in its present form in 1987, but the southern part (640 ha south of Hornsby Rifle Range) has been a reserve, Elouera Bushland Natural Park, since 1964. The Park is administered by Hornsby Shire Council.

Smith and Smith (1990) carried out a detailed survey of the Park. They distinguished 17 plant communities; forest, woodland, heath and swamp communities associated with the dominant Hawkesbury Sandstone geology; taller eucalypt and low rainforest associated with more fertile soils; and eucalypt, *Casuarina*, mangrove and saltmarsh communities associated with the wider, tidal reaches of Berowra Creek. Several communities in the Park are poorly represented in other reserves. Especially important are taller forest communities characterised by *Eucalyptus saligna* and *Eucalyptus pilularis*.

Berowra Valley Bushland Park has a very rich flora, as is typical of vegetation on Hawkesbury Sandstone. A total of 517 native vascular plant species have been recorded. Ten of these species are on the national list of rare and threatened plants, including three species classified as vulnerable: *Eucalyptus camfieldii*, *Darwinia biflora* and *Tetratheca glandulosa*. Another four rare or threatened species have been recorded nearby and may also occur in the Park.

Bicentennial Park/Homebush Bay

Originally, Homebush Bay had the largest expanse of estuarine vegetation in Sydney Harbour, but this has been gradually reduced by extensive landfill projects beginning in the 1890s (Kachka 1993, Clarke & Benson 1988). Mangrove and some other wetland vegetation has been protected in Bicentennial Park, where boardwalks and an active environmental awareness program make these areas accessible. However, more important and undisturbed wetlands with extensive areas of saltmarsh, including populations of *Wilsonia backhousei*, *Halosarcia pergranulata* var. *pergranulata* and *Lampranthus tegens*, together with remnant Turpentine-Ironbark Forest (Map unit 9o) survive on military land at Silverwater. These areas are important because they have been protected from human disturbance — reports indicate a particularly high and abundant reptile fauna in the woodland — and should be maintained as limited access areas.

Botany Bay National Park (Cape Banks)

Vegetation at Cape Banks, Henry Head and La Perouse is part of Botany Bay National Park. Vegetation is mainly heath and open-forest on Hawkesbury sandstone,



Figure 22. Mangroves, *Avicennia marina*, and saltmarsh, *Sarcocornia quinqueflora*, along Haslems Creek in Homebush Bay (map unit 4a). It is hoped that these will be retained during the development of the Olympic Games site.

and open-scrub of *Banksia integrifolia* on beach sand (Armstrong, Benson & Coveny 1976). The area is rich in native species, though the exotic weed, *Chrysanthemoides monilifera*, originally introduced to stabilise sand dunes, is a major problem in some areas. A small remnant of Pleistocene sand at Jennifer Street, La Perouse has *Banksia aemula* heath as well as important associated wetland vegetation, and has been recommended for conservation.

Bouddi National Park

Bouddi National Park is situated on the northern headland of Broken Bay, 45 km north of Sydney. Its vegetation has been described and mapped by McRae (1990), who described 15 plant communities related to habitat elements such as geology, geomorphology, climate and soil. The main components of the geology are Hawkesbury Sandstone and Narrabeen Series and the Park is important for the extensive areas of coastal vegetation on the latter. These include coastal grassland, heath and woodland and palm-dominated open-forest. A good account of the landscape, natural history and landuse is given in Strom (1986).

Brisbane Water National Park

The vegetation of Brisbane Water National Park has been described and mapped by Benson, J.S. and Fallding (1981). They described 15 plant communities; low open-forest, low open-woodland and open-woodland with dry or moist shrub understorey



Figure 23. The effect of different drainage conditions can be seen here in Brisbane Water National Park — sedgeland on shallow poorly-drained soil in the foreground contrasts with woodland on better-drained soil.



Figure 24. There is a small remnant of Turpentine Ironbark Forest on the clay soil above Cooks River at Campsie — a rare survivor of native vegetation along the River.

on the ridges and slopes of Hawkesbury Sandstone; open-forest on cooler aspects and on Narrabeen Group outcrops along the watercourses; sedgelands and open-scrub in higher, poorly-drained sites; coastal heath and rock outcrops with pockets of heath; closed-forest with rainforest species in valleys or along creeks, mainly on the Narrabeen group; and mangroves and rushland along tidal watercourses. A total of 657 native and exotic plant species were recorded. This includes ten considered to be rare or at risk.

Cooks River–Wolli Creek Valley

Though not primarily conserved as a nature reserve, remnants of native vegetation in Cooks River–Wolli Creek are the only remaining natural areas in inner south-western Sydney and need careful management. Cooks River includes very small localised patches of mangroves and reedland of *Phragmites australis*, and remnants of Turpentine–Ironbark Forest at Campsie (Benson 1992b) (see also Map unit 9o description). Vegetation at Wolli Creek includes eucalypt forest and heath on Hawkesbury Sandstone, freshwater marsh, saltmarsh and mangroves (Benson 1978b, Robinson 1986, 1987, Brown et al. 1988).



Figure 25. The Cooks River is mainly confined to a concrete or iron-lined channel, but here at Canterbury native reeds *Phragmites australis* grow on the bank. The rehabilitation of other bank sections using native species and the development of semi-natural vegetation with adjacent tree and shrub planting will provide much-needed wildlife habitat along the River and improve its appearance.



Figure 26. Creeks in sandstone gullies such as this in Garigal National Park provide sheltered and pleasant conditions. *Tristaniopsis laurina* is a frequent streamside species.

Cumberland and Darling Mills State Forests

These two forest areas together with the adjoining IBM Forest, demonstrate the influence of soil and geological changes on vegetation. Cumberland State Forest (40 ha) at West Pennant Hills has Wianamatta Shale soils with remnants of Blue Gum High Forest (Map unit 6b). Tree species include *Eucalyptus saligna*, *Eucalyptus paniculata*, *Eucalyptus tereticornis*, *Eucalyptus acmenoides* and *Angophora floribunda*. Darling Mills State Forest (50 ha) at North Rocks, 2 km further south and adjacent to Excelsior Park is dominated by massive outcrops of Hawkesbury Sandstone forming significant cliff faces, rock ledges and overhangs with a succession of sandstone terraces and escarpments. Vegetation here includes dry woodland of *Angophora bakeri* and *Eucalyptus gummifera* with shrubs of *Acacia linifolia*, *Leptospermum polygalifolium*, *Banksia serrata* and *Hakea sericea* as well as heath. Moist forest with *Eucalyptus pilularis*–*Eucalyptus saligna* and *Eucalyptus pilularis*–*Angophora costata*–*Eucalyptus piperita* is restricted to alluvial flats and sheltered hillsides. Details of these areas are given in the Forestry Management Plan (Forestry Commission of NSW 1984).

Dalrymple–Hay Nature Reserve

The need to conserve some remnants of such an impressive plant community as the Blue Gum High Forest (Map unit 6b) was recognised as far back as the 1930s when most of the forest had already been destroyed for farming or suburbs. At that time the NSW Forestry Commission planned to subdivide part of their Dalrymple–Hay State Forest at St Ives, but as a result of local action this Forest was preserved and later transferred to the National Parks and Wildlife Service as the Dalrymple–Hay

Nature Reserve. This Reserve has an area of 11 ha of *Eucalyptus pilularis*, *Eucalyptus paniculata*, *Angophora costata* and *Syncarpia glomulifera* trees with a shrub understorey on higher ground, and *Eucalyptus saligna* with a fern understorey along the main watercourse (Benson & Keith 1984a).

Garigal National Park — Narrabeen Lagoon catchment

The vegetation of Garigal National Park (Narrabeen Lagoon catchment) (approx. 820 ha) has been recently described and mapped by Sheringham and Sanders (1993) in an excellent report for the NSW National Parks and Wildlife Service. They describe and map 21 plant communities. These include extensive areas of heathland, woodland and open-forest on Hawkesbury Sandstone (Map units 10ar, 10ag, 21g) as well as much more limited and restricted areas of forest on remnant shale sites (9sf) and freshwater and estuarine reedland herbfield, paperbark swamp and swamp forest (27a).

Sheringham and Sanders (1993) found that differences in the major geological types, alluvial-sedimentary, were the main environmental influence on vegetation distribution, but that differences between shale and sandstone were less important. For vegetation on alluvial areas the depth, period of inundation and salinity of water are the major factors influencing species composition. The types with the highest conservation significance were the freshwater wetlands and swamps along the Deep Creek floodplain, and shale and lateritic forests restricted to the ridge along Forest Way and Mona Vale Road. Many of the wetlands are outside the Park boundary and have been recommended for addition to the Park as a matter of priority.

A list of over 600 species (both native and exotic) has been compiled for the National Park (Narrabeen Lagoon catchment) and surrounding Crown lands including species of national significance — *Grevillea caleyi*, *Tetratheca glandulosa*, *Eucalyptus luehmanniana*, *Lomandra brevis*, *Lomandra fluviatilis*, *Platysace stephensonii*, *Darwinia procera*, *Persoonia hirsuta*, *Genoplesium baueri*, *Hibbertia nitida* and *Angophora crassifolia* (Sheringham & Sanders 1993).

Garigal National Park — Middle Harbour Creek catchment

The vegetation types represented within the Middle Harbour Creek part of Garigal National Park (former Davidson State Recreation Area) include forest, woodland, heathland, scrubland, mangrove and saltmarsh, and vegetation of creek banks containing mesic species. Vegetation of particular importance includes areas of Coastal Sandstone Heath (map unit 21g), now scarce in Sydney due to urban spread. Examples may be seen on ridgetop areas of the Park — along the Cook St trail, parallel to Wakehurst Parkway above Bantry Bay, at the end of Matthews St, Davidson, and along part of the Stone Parade track to the Cascades. There is a significant stand of the rare mallee *Eucalyptus luehmanniana* in woodland on a south aspect slope beneath The Bluff.

There are also small remnants of ridgetop vegetation on the shale-sandstone transition, with soils rich in ironstone gravels. These remnants contain relatively uncommon species such as *Boronia rigens*, *Baeckea ramosissima* and *Leucopogon appressus*.

Vegetation along Bare Creek and upper Middle Harbour Creek includes the nationally significant species *Lomandra fluviatilis* and what is probably the largest known population of *Leptospermum deanei*. Further down Middle Harbour Creek are *Hibbertia nitida* and *Darwinia procera*. In upper-level creek sites, with more exposure to sunlight, are relatively uncommon plants with specific habitat requirements such as *Symphionema paludosum* and *Sprengelia incarnata*.

Gullies contain locally uncommon plant species such as *Cymbidium suave*, *Leucopogon lanceolatus* and *Boronia thujona* on the slopes. *Dracophyllum secundum*, *Rimacola elliptica* and *Epacris crassifolia* are found in crevices of rocky overhangs. Closer to the creeks are *Stenocarpus salignus*, *Lomatia myricoides*, *Drosera binata*, *Leucopogon amplexicaulis*, *Lycopodium deuterodensum*, *Blechnum ambiguum*, *Austromyrtus tenuifolia*, and *Hymenophyllum cupressiforme*. The very restricted shrub *Haloragodenron lucasii* occurs on an upper slope near Barra Brui.

Mangrove and saltmarsh are found in Bantry Bay and in Middle Harbour Creek and along tributaries from Roseville Bridge, upstream.

Georges River National Park

Hawkesbury Sandstone outcrops along the foreshores of the Georges River below East Hills. Downstream from here the river has the typical 'drowned valley' appearance characteristic of Sydney Harbour and Broken Bay. Georges River National Park includes foreshores downstream from Salt Pan Creek. Natural vegetation here is mostly woodland of *Angophora costata*, *Eucalyptus gummifera* and *Eucalyptus punctata*. On drier slopes are *Angophora bakeri* and *Allocasuarina littoralis*, while small patches of heath with *Angophora hispida* are found on some of the gravelly ridge-tops (Benson & Howell 1990a). Salt Pan Creek has areas of mangroves and saltmarsh.

Katandra Bushland Sanctuary

Katandra Bushland Sanctuary is a small reserve (11.5 ha) at Ingleside managed by a Department of Conservation and Land Management trust. Geology is Hawkesbury Sandstone with minor shale lenses, the aspect is easterly and the vegetation is mostly open-forest with closed-forest along the major creek lines. Main tree species include *Angophora costata*, *Eucalyptus gummifera*, *Eucalyptus piperita*, *Eucalyptus punctata* and *Eucalyptus umbra* (Map unit 10ag). The vegetation is generally moist and sheltered and includes species that are generally uncommon in Sydney including *Eucalyptus scias*, a tall tree in this habitat, the rainforest trees *Cryptocarya glaucescens*, *Cryptocarya microneura* and *Endiandra sieberi*, the shrubs *Bertya brownei*, *Boronia mollis*, *Boronia thujona*, *Prostanthera denticulata*, *Eupomatia laurina*, *Wilkia huegeliana*, *Maytenus silvestris*, *Oxylobium ilicifolium*, *Correa reflexa*, and a vine *Passiflora cinnabarina*. *Cetatopetalum apetalum* is common along the creek lines with *Trochocarpa laurina*, *Livistona australis*, the tree fern *Cyathea australis* and the cycad *Macrozamia communis*. The uncommon, primitive fern *Tmesipteris truncata* grows on trunks of *Todea barbara*, while *Psilotum nudum* is often found in rock crevices, and *Hymenophyllum cupressiforme* and *Grammitis billardieri* are found on damp rock surfaces. There are a large number of orchids including several species of *Acianthus*, *Pterostylis* and *Cryptostylis*, also *Gastrodia*

sesamoides, *Chiloglottis reflexa*, *Corybas aconitiflorus*, *Dendrobium speciosissima* and *Dendrobium linguiforme* on rocks, *Lyperanthus suaveolens* on damp rocks and *Cymbidium suave* in trees.

On the upper slope are sandstone woodland species including *Banksia ericifolia* and *Banksia serrata*, *Xanthorrhoea media*, *Xanthorrhoea arborea*, *Phebalium dentatum* and *Acacia oxycedrus*. With *Gahnia clarkei*, three species of *Gleichenia* form dense thickets in a hanging swamp.

Ku-ring-gai Chase National Park

Ku-ring-gai Chase National Park (14 709 ha) is one of the major national parks of the predominantly sandstone Hornsby Plateau north of Sydney.

The nature and distribution of the vegetation is strongly related to geology, soil, drainage and aspect. Thomas and Benson (1985a) recognised 21 plant communities. There is considerable variation within some communities and intergradation between communities is a common feature. A floristic analysis of the vegetation has been carried out by Outhred et al. (1985).

As a conservation area, Ku-ring-gai Chase National Park is particularly important for its large area of relatively undisturbed vegetation of the type that gives Sydney bushland its distinctive character. It is also important for conserving vegetation types that are significant in a regional and local context. These tend to be of limited size and are associated with unusual or remnant geological and topographical



Figure 27. Extensive areas of sandstone country with woodland, heath and forest make up Ku-ring-gai Chase and Brisbane Water National Parks — here looking from Warrah Lookout towards Patonga Beach.

features e.g. Duffys Forest vegetation (map unit 9sf) and *Eucalyptus maculata*–*Eucalyptus paniculata* open-forest (part of map unit 9g).

A total of 566 native species from 119 families were recorded by Thomas and Benson (1985a), though Rose (1982) recorded 975 species, both native and exotic, over a longer period. Significant species recorded in Ku-ring-gai Chase include *Lomandra brevis*, *Genoplesium baueri*, *Leucopogon amplexicaulis*, *Austromyrtus tenuifolia*, *Darwinia biflora*, *Darwinia procera*, *Eucalyptus leuhmanniana*, *Eucalyptus squamosa*, *Grevillea caleyi*, *Boronia fraseri*, *Rulingia hermannifolia*, *Tetratheca glandulosa*, *Cryptostylis hunterana*, *Eucalyptus camfieldii*, *Blechnum ambiguum* and *Kunzea rupestris* (Thomas & Benson 1985a).

Fire is an important factor affecting vegetation in many Sydney bushland areas. Many species have adaptive mechanisms that enable them to survive individual fires, but frequent fires with only short periods between them may lead to possible long-term changes to vegetation with some species being lost; fire-free periods of at least 10 years are desirable for much of the vegetation to allow replenishment of plant seedbanks etc. (Thomas & Benson 1985a, Benson 1985).

As for other 'urban' national parks, weed invasion in Ku-ring-gai Chase is a serious problem, and is associated with run-off from urban development, areas of past habitation within the Park, tracks, watercourses, border areas, specific areas of high public usage and some small areas of undisturbed bushland.

The map showing the vegetation of Ku-ring-gai Chase National Park and the adjacent Muogamarra Nature Reserve prepared by Thomas and Benson (1985a) has been reproduced without change at a reduced scale (1:40 000 scale, 2 cm = 1 km), on the back of the Sydney 1:100 000 Vegetation Map Sheet. It shows more detail than the 1:100 000 sheet, for example map unit 10ar is divided into five units. Relationships between the two maps are given in Table 3.

Table 3. Plant communities in Ku-ring-gai Chase National Park and Muogamarra Nature Reserve

Summarised descriptions give map code, structure, habitat, geology and dominant species based on Thomas and Benson, 1985, *Vegetation survey of Ku-ring-gai Chase National Park* (Royal Botanic Gardens Sydney). Code in brackets at end shows relevant map unit for Sydney 1:100 000 map sheet.

1 Closed-forest

Tristaniopsis laurina, *Ceratopetalum apetalum*

Gully Rainforest in sheltered gullies close to sea level, Hawkesbury Sandstone soils (**10ag**).

2 Low closed-forest/Closed-forest with emergent trees

Acmena smithii, *Glochidion ferdinandi*, *Livistona australis*, emergents —*Eucalyptus botryoides*, *Angophora floribunda*

Rainforest with emergent eucalypts. Sheltered slopes, mostly western Pittwater, Narrabeen Group soils (**9h**).

3 Tall open-forest/Open-forest

Eucalyptus agglomerata, *Angophora floribunda*, *Allocasuarina torulosa*

Confined to breccia in Campbells Crater (**6c**).

4 Open-forest

Eucalyptus paniculata, *Eucalyptus umbra*, *Eucalyptus scias*, *Syncarpia glomulifera*, *Angophora floribunda*
Clay soils from weathered volcanic dyke at West Head **(6c)**.

5 Open-forest

Eucalyptus maculata, *Eucalyptus paniculata*, *Syncarpia glomulifera*, *Allocasuarina torulosa*
Western Pittwater, on Narrabeen Group shales **(9g)**.

6 Open-forest

Angophora floribunda, *Eucalyptus paniculata*, *Eucalyptus botryoides*, *Eucalyptus scias*, *Syncarpia glomulifera*, *Allocasuarina torulosa*
Sheltered slopes, Western Pittwater, Narrabeen Group shales and sandstones **(9h)**.

7 Open-forest

Angophora floribunda, *Eucalyptus punctata*, *Allocasuarina torulosa*
Footslopes above saltwater estuaries and foreshores of Cowan Creek, Coal and Candle Creek, Smiths Creek and Hawkesbury River. Mostly Narrabeen Group **(9h)**.

8 Open-forest

Eucalyptus pilularis, *Eucalyptus resinifera*, *Angophora costata*, *Syncarpia glomulifera*
Upper Cockle Creek valley on Wianamatta Shale soils **(9o)**.

9 Open-forest

Eucalyptus piperita, *Angophora costata*, *Eucalyptus gummifera*, *Eucalyptus umbra*, *Syncarpia glomulifera*
Sheltered aspects on slopes, particularly steep south-facing slopes, Hawkesbury Sandstone soils including podsols **(10ag)**.

10A Open-forest

Eucalyptus capitellata, *Eucalyptus gummifera*, *Eucalyptus sieberi*, *Eucalyptus haemastoma*
Along Mona Vale Road on 'lateritic' soils from shale lenses now exposed as cappings on plateaus over Hawkesbury Sandstone **(9sf)**.

10B Open-forest/Low open-forest

Eucalyptus sieberi, *Eucalyptus gummifera*, *Eucalyptus sparsifolia*, *Eucalyptus haemastoma*
At Duffys Forest on 'lateritic' soils from shale lenses now exposed as cappings on plateaus over Hawkesbury Sandstone **(9sf)**.

11 Low open-forest

Eucalyptus racemosa, *Eucalyptus gummifera*, *Eucalyptus sparsifolia*, *Eucalyptus sieberi*
On flat ridgetops e.g. Windybanks Ridge, on Hawkesbury Sandstone with yellow-earth soils, clay sub-soils and ironstone fragments **(10ar)**.

12 Low open-forest with patches of Grassland

Allocasuarina torulosa, *Allocasuarina littoralis*, *Banksia integrifolia*, emergent trees: *Angophora costata*, *Eucalyptus botryoides*
Exposed sites on headlands with clay soils from the Narrabeen Group **(21a)**.

13 Woodland

Angophora costata, *Eucalyptus gummifera*, *Eucalyptus umbra*, *Allocasuarina littoralis* and (west of Cowan Creek) *Eucalyptus eximia*
Moderate to steep slopes, exposed aspects on Hawkesbury Sandstone **(10ar)**.

14 Low woodland

Eucalyptus camfieldii, *Eucalyptus haemastoma*, *Eucalyptus gummifera*
Clay soil with ironstone fragments on Hawkesbury Sandstone. Very restricted, West Head Road/Elvina Bay Track **(10ar)**.

15 Low woodland/Low open-woodland

Eucalyptus gummifera, *Eucalyptus haemastoma*, *Eucalyptus sparsifolia*, *Eucalyptus eximia* (west of Cowan Creek), *Angophora bakeri* (in Muogamarra Nature Reserve). Low slope plateau areas: crests, spurs and upper slopes on Hawkesbury Sandstone **(10ar)**.

16 Low open-woodland (mallee)

Eucalyptus luehmanniana

Seepage zones on upper slopes with southerly aspects on Hawkesbury Sandstone. Uncommon **(10ar)**.

17 Closed scrub/Scrub-heath

Banksia ericifolia, *Hakea teretifolia*, *Allocasuarina distyla*, *Leptospermum trinervium*, *Angophora hispida*, emergents — *Eucalyptus haemastoma*, *Eucalyptus gummifera*

Poorly-drained areas on the plateaus, low slope areas on ridges, hillsides and sandstone benches and thin skeletal soils on ridgetops. Hawkesbury Sandstone **(21g)**.

18 Pockets of Heath on rocky outcrops

Baeckea brevifolia, *Baeckea diosmifolia*, *Kunzea capitata*, *Calytrix tetragona*, *Darwinia fascicularis* subsp. *fascicularis*, *Allocasuarina distyla*

Exposed rock platforms with shallow depressions, Hawkesbury Sandstone **(21g)**.

19 Tall open-scrub

Avicennia marina, *Aegiceras corniculatum*

Mangroves along tidal watercourses and mud flats. Mainly limited to Upper Cowan Creek, Smiths Creek, Cockle Creek and Porto Bay, Kimmerakong Bay, Joe Crafts Bay and Peats Bight **(4a)**.

20 Reedland/Rushland and Casuarina Woodland

Juncus kraussii, *Phragmites australis*, *Sarcocornia quinqueflora*, *Baumea juncea*, *Sporobolus virginicus*, *Casuarina glauca*

Alluvial flats associated with tidal creeks, on landward side of Mangroves (Community 19) **(4a)**.

21 Sedgeland/Shrubland

Gahnia sieberiana, *Empodisma minus*, *Leptocarpus tenax*, *Schoenus brevifolius*, *Gymnoschoenus sphaerocephalus*, *Xyris operculata*, shrubs — *Banksia robur*, *Sprengelia incarnata*, *Viminaria juncea*, *Callistemon citrinus*

Areas of impeded drainage with a consistently high watertable, Hawkesbury Sandstone **(21g)**.

Lane Cove River National Park

The Lane Cove River has incised a narrow valley through Ashfield Shale and Hawkesbury Sandstone. Since the rise in sea level about 6 000 years ago, the river and its tributaries have deposited alluvium in the lower river and estuary. Microclimatic variations resulting from differences in solar radiation due to aspect, slope and horizon factors have a major role in influencing vegetation patterns within various landscape types.

Lane Cove River National Park (formerly State Recreation Area) (400 ha in area) occupies a 10 km strip along the Lane Cove River from Browns Waterhole to Fullers Bridge. Surrounded by suburbs, it is probably one of the most intensively used bushland parks in Sydney.

Historical changes affecting fire regimes and vegetation patterns in the Lane Cove valley, particularly since the arrival of Europeans, have been studied by McLoughlin (1985) and Clark and McLoughlin (1986). The present vegetation of the National Park has been described by Clarke and Benson (1987), who recognise 15 plant

communities and record the occurrence of approximately 360 native species. Species of significance include *Darwinia biflora*, *Leptospermum deanei*, *Eucalyptus squamosa*, *Austromyrtus tenuifolia*, *Epacris crassifolia*, *Boronia polygalifolia* and *Leucopogon amplexicaulis*.

The lower valley is characterised by wide alluvial flats that are often intertidal and saline. Vegetation types include mangrove, saltmarsh and rushland. Although the alluvial deposits along the river have always been high in nutrient status they have probably been significantly enriched by run-off and siltation from urbanisation. Alluvial deposits become extensive in the middle section of the river where minor floodplains occur. Vegetation types include tall forest of *Eucalyptus pilularis*–*Eucalyptus saligna* (Map unit 6b) and *Eucalyptus pilularis*–*Eucalyptus piperita*–*Syncarpia glomulifera* (Map unit 10ag). Flooding of the Lane Cove River is a major factor influencing the alluvial vegetation, with minor floods depositing fine silt and weeds onto river flats.

Lower slopes and hills below Ashfield Shale have Hawkesbury Sandstone as their parent material and consist mainly, though not exclusively, of coarse sandstone. Minor shale and laminite lenses occur. These produce benches and breaks in the boulder-strewn landscape. Nutrient deficient lithosols are the main soil type on Hawkesbury Sandstone, although deeper yellow podzolic soils and red podzolic soils may develop on shale lenses. Open-forest of *Angophora costata*–*Eucalyptus piperita*–*Eucalyptus gummifera*, closed shrubland of *Banksia ericifolia*–*Leptospermum trinervium*–*Angophora hispida*, riparian shrubland of *Tristaniopsis laurina*–*Callicoma serratifolia*–*Lomatia myricoides* and woodland of *Eucalyptus racemosa*–*Eucalyptus gummifera*–*Allocasuarina littoralis* (Map unit 10ar) occur on these Hawkesbury Sandstone soils. The nutrient levels in some of these soils have been increased by urban run-off (Clements 1983).

Wianamatta Group Ashfield Shale (laminite and dark grey siltone) occurs on upper ridges, forming an undulating landscape with gentle slopes. Soils vary between brown and red podzolics on upper slopes to red and yellow podzolics on lower slopes and valleys. Open-forest of *Eucalyptus resinifera*–*Syncarpia glomulifera* (Map unit 9o) occurred here but has been mostly cleared. Numerous shale fragments near the surface of these soils are often a feature where they overlie Hawkesbury Sandstone.

As an area of natural vegetation containing this variety of habitats and plant communities within the suburban context, Lane Cove provides environmental experiences and education for a significant local and regional population. The range of landscapes in Lane Cove River National Park differ from those in the national parks of the upper Hornsby plateau and the Woronora Plateau; in particular the alluvial valley soils have more clay influence from the Wianamatta Shale of the surrounding ridgetops. With the added influence of the higher rainfall at this location, these valleys support types of tall forest now rare in the metropolitan area.

Lion Island Nature Reserve

Lion Island (8 ha), situated at the entrance to Broken Bay, is similar geologically to the nearby Brisbane Water National Park, with a Hawkesbury Sandstone capping on the eastern end and strata of the underlying Narrabeen Group exposed else-



Figure 28. Woodland with the twisted limbs of *Angophora costata* and understorey of *Xanthorrhoea arborea* on Lion Island in Broken Bay.

where. The main vegetation on the eastern end is low woodland of *Angophora costata* and *Eucalyptus botryoides*, with shrubs of *Banksia serrata*, *Exocarpos cupressiformis*, *Xanthorrhoea arborea*, *Platysace lanceolata*, *Hakea sericea*, *Dodonaea triquetra* and *Acacia ulicifolia* (Benson 1981a).

At the western end of the island is low open-forest of *Banksia integrifolia* and *Allocasuarina littoralis*. On more exposed sites this grades into scrub with *Leptospermum laevigatum* and *Banksia integrifolia*. The exotic *Lantana camara* is common in these situations.

On scree slopes at the eastern end of the island and exposed to the ocean is herbland with *Commelina cyanea*, *Lobelia alata* and *Dichondra repens*. Shrubs of *Westringia fruticosa* are found in cracks between large sandstone boulders and higher up in cracks and ledges on the cliff faces. Benson (1981a) gives a species list for the island.

Long Island Nature Reserve

Long Island Nature Reserve (73 ha), adjacent to Brooklyn, is a long narrow east-west oriented ridge and has similar vegetation to other Hawkesbury Sandstone islands such as Spectacle Island, although it has very little plateau vegetation.

Manly-Warringah War Memorial Park

Manly-Warringah War Memorial Park (480 ha), managed by Warringah Shire Council, is mostly catchment of Manly Reservoir and is surrounded by the suburbs of Frenchs

Forest, Allambie Heights, North Manly and Balgowlah; Wakehurst Golf Course and Garigal National Park. The geology is Hawkesbury Sandstone with some shale lenses. Much of the vegetation is woodland of *Eucalyptus gummifera* and *Eucalyptus haemastoma*; *Angophora crassifolia*, a small tree or mallee found only in the eastern parts of the Hornsby Plateau, is in low woodland near Frenchs Forest and there are small patches of *Eucalyptus obstans* in heath near Allambie Heights. On shallow soil on the ridges is heathland (Map unit 21g); shrubs are *Leptospermum trinervium*, *Darwinia fascicularis*, *Kunzea ambigua*, *Angophora hispida*, with *Actinotus helianthi*, *Blandfordia nobilis*, *Leucopogon* and *Epacris* species. *Allocasuarina distyla* and *Banksia ericifolia* are dominant in taller shrubland with *Banksia oblongifolia* and *Hakea teretifolia* in poorly-drained soil. In sheltered gullies is open-forest, mainly *Eucalyptus piperita* and *Angophora costata*. Shrub species in woodland/open-forest include *Dodonaea triquetra*, *Acacia terminalis*, *Persoonia pinifolia*, *Persoonia linearis*, *Pultenaea flexilis*, *Dillwynia retorta*, *Boronia pinnata*, *Crocea saligna*, *Eriostemon australasius*, *Ceratopetalum gummiferum*, and *Telopea speciosissima*. Some species restricted to creek lines are *Tristaniopsis laurina*, *Ceratopetalum apetalum*, *Callicoma serratifolia*, *Baeckea linifolia*, *Austromyrtus tenuifolia* and an uncommon sedge *Restio tetraphyllus* subsp. *meiostachys*. An uncommon orchid *Rimicola elliptica* was recorded on a moist rock ledge. Important wetland vegetation with *Eleocharis sphacelata*, *Juncus* species, *Baumea nuda*, *Philydrum lanuginosum*, *Persicaria decipiens*, *Schoenus melanostachys*, and *Schoenus brevifolius* provides habitat for birds at the northern end of the reservoir.

Marramarra National Park

Marramarra National Park is a major reserve (11 760 ha) northwest of Sydney, between the Hawkesbury River, Old Northern Road and Berowra Creek. It is mainly Hawkesbury Sandstone plateau country with some narrow cappings of Wianamatta Shale, mostly cleared, and several volcanic necks. The area is generally drier than Ku-ring-gai Chase National Park further east.

Mangroves, *Avicennia marina* and *Aegiceras corniculatum* grow in saline conditions on mudflats in bays and tidal stretches of creeks. These often have *Duboisia myoporoides* on the banks. Creek vegetation above the tidal limit, includes *Tristaniopsis laurina*, *Backhousia myrtifolia*, *Trochocarpa laurina*, *Leptospermum grandifolium* and occasionally *Leptospermum deanei*. The rare local endemic *Asterolasia elegans* is found on sheltered slopes near creeks, though *Asterolasia correifolia* is more common here. *Boronia fraseri*, *Boronia anemonifolia*, *Darwinia peduncularis*, *Prostanthera rhombea*, *Zieria involucrata*, and *Lasiopetalum macrophyllum* occur occasionally on creekbanks.

In gullies approaching Coba Bay, possibly with volcanic influence, there is tall open-forest of *Eucalyptus agglomerata*, with *Angophora floribunda* extending to the flats. *Platysace clelandii* is occasional on lower sheltered slopes here with *Allocasuarina torulosa*. In gullies, and on slopes with east to southerly aspects, is open-forest of *Eucalyptus piperita*, *Angophora costata* and *Allocasuarina littoralis* (map unit 10ag) with *Eucalyptus gummifera* and *Eucalyptus sparsifolia* in low open-forest on the edge of ridges (map unit 10ar).

Vegetation on dry ridges (and slopes with north to westerly aspect) is low-woodland to woodland of mainly *Eucalyptus eximia* and *Eucalyptus haemastoma*, often with *Eucalyptus punctata* and *Eucalyptus gummifera*. *Hakea bakeriana* occurs in small patches in woodland on ridges, *Doryanthes excelsa* also occurs north of Canoelands Ridge. There are occasional occurrences of *Eucalyptus squamosa* and patches of *Angophora bakeri*. On rocky parts, *Eucalyptus eximia* is interspersed with low shrubland, often with patches of *Grevillea linearifolia* (narrow-leaved form) and *Dillwynia sericea*. Common shrubs are *Zieria laevigata*, *Gompholobium grandiflorum*, *Leucopogon muticus* and less commonly *Eriostemon hispidulus*. A disjunct population of the south coast species, *Dampiera scottiana* occurs in *Eucalyptus haemastoma* woodland. Populations of *Kunzea rupestris* are rare on rock platforms and *Micromyrtus blakelyi* has been found in a similar habitat. There are some rocky ridgetops in the Park but only very limited areas of heath and sedgeswamp vegetation. Marramarra National Park is an important link between the coastal sandstone vegetation e.g. in Ku-ring-gai, and the more inland vegetation of the Blue Mountains and Wollemi regions.

Muogamarra Nature Reserve

Muogamarra Nature Reserve (2 234 ha) lies north of the suburbs of Cowan and Berowra Heights, and is bounded by Berowra Creek, the Hawkesbury River, the Pacific Highway and Main Northern Railway. To the east and west lie Ku-ring-gai Chase and Marramarra National Parks respectively, while north of the Hawkesbury is Brisbane Water National Park. Muogamarra forms an integral part of the landscape of northern Sydney and conserves a significant portion of the Sydney sandstone bushland.

The vegetation of Muogamarra has been described by Thomas and Benson (1985b) and mapped with the Ku-ring-gai map (see map on back of Sydney 1:100 000 sheet). The nature and distribution of the vegetation is strongly related to geology, soil, drainage and aspect. Within Muogamarra 11 plant communities were recognised including closed-forest, open-forest, low open-forest, woodland, low woodland/low open-woodland, closed scrub/scrub-heath, pockets of heath on rocky outcrops, tall open-scrub, reedland/rushland with woodland, and sedgeland/shrubland. There is considerable variation within some communities and intergradation between communities is a common feature.

Weed invasion is generally of minor significance, with the exception of the Peats Crater area, and is restricted to a few localised sites and some general occurrences along tracks.

Over 400 species from 95 families were recorded by Thomas and Benson (1985b). Significant species include *Lomandra brevis*, *Tetratheca glandulosa*, *Boronia fraseri*, *Micromyrtus blakelyi*, *Platysace clelandii*, *Austromyrtus tenuifolia*, *Eucalyptus squamosa* and *Blechnum ambiguum*.

Spectacle Island Nature Reserve

Spectacle Island Nature Reserve (36 ha) is a small island in the Hawkesbury River, near its junction with Mooney Mooney Creek. It is about 1 200 m long and 600 m wide, up to 120 m high, and capped with Hawkesbury Sandstone which overlies Narrabeen strata that outcrop along the lower slopes. Vegetation, described by Webb (1981), is similar to that of the nearby Brisbane Water and Ku-ring-gai Chase National Parks. On the flat sandstone top of the island is open-woodland with trees of *Eucalyptus gummifera* and *Angophora costata* with an open understorey of *Imperata cylindrica* and scattered shrubs of *Banksia marginata*, *Xylomelum pyrifforme*, *Gompholobium latifolium* and *Kunzea ambigua* (map unit 10ar). This extends onto the steep, upper sandstone slopes. On the lower slopes, on soils from Narrabeen strata, trees of *Angophora floribunda* with a grassy understorey predominate on the north-facing slopes, *Eucalyptus punctata* on the relatively flat western end of the island, and denser vegetation with *Acacia elata*, *Allocasuarina torulosa* and *Allocasuarina littoralis* on the steep southern slopes. There are mesic gully species at the base of the sandstone cliffs on the southern side. This is all part of the Narrabeen Slopes Forest (map unit 9h).

Sydney Harbour National Park

Sydney Harbour National Park includes a number of significant areas of vegetation associated with the Harbour foreshores and islands. Substantial areas of North Head including the former Quarantine Station, Dobroyd Head, Middle Head, Bradleys Head and Ashton Park, parts of South Head and Nielsen Park, and Shark, Clark and Rodd Islands are included, though the original bushland on the islands has generally been cleared. Many of these areas were formerly military land and include a scattering of military relics within the bushland.

Remaining vegetation is almost all on Hawkesbury Sandstone, with the soils and degree of exposure to salt-laden sea spray together determining the structure and floristic composition. Exposed sites on shallow soils particularly on North Head and Dobroyd Head have Coastal Sandstone Heath (map unit 21g) which, because of the immediate coastal influence, includes shoreline species such as *Baeckea imbricata*, *Westringia fruticosa*, *Olearia tomentosa* and *Melaleuca hypericifolia* (see Adam, Stricker et al. 1989) as well as coastal heath of *Banksia ericifolia*-*Darwinia fascicularis*. In more sheltered sites open-forest and woodland with *Angophora costata*, *Eucalyptus botryoides*, *Eucalyptus gummifera* occur. A very restricted patch of Coastal Dune Heath (map unit 21b) with *Eucalyptus camfieldii* (Horton 1986) occurs on North Head.

Wallumatta Nature Reserve

Wallumatta Nature Reserve is a small reserve (about 5 ha) in East Ryde that retains an example of the Turpentine-Ironbark Forest of the Wianamatta Shale in areas of moderate rainfall (i.e. 900–1100 mm p.a.). In the metropolitan area only about 0.5% of this forest remains. Wallumatta includes over 90 plant species of the shale flora with a transition zone from shale to sandstone vegetation (Benson & Keith 1984c). The nearby Field of Mars Reserve includes good areas of sandstone but very little shale vegetation.

The National Parks and Wildlife Service, in association with the Ryde-Hunters Hill Flora and Fauna Preservation Society, has established a joint committee to oversee Wallumatta. Because it is a particularly important example of Sydney's remnant vegetation it will be used mainly for education, research and nature study.



Figure 29. Heath and woodland at Dobroyd Head in Sydney Harbour National Park after an extensive fire in 1990. Periodic fire is an important factor in maintaining species composition in heathland.

Table 4. Native plant species recorded from major conservation areas in the Sydney map sheet area

Species are arranged alphabetically within families and major groups. List is based on various references (see below) with some additions by Doug Benson and Lyn McDougall. Areas are ordered north to south, with codes as follows.

Bd	Boudi National Park (McRae 1990)
BW	Brisbane Water National Park (Benson & Fallding 1981)
Li	Lion Island Nature Reserve (Benson 1981a, McDougall 1989)
Sp	Spectacle Island Nature Reserve (Webb 1981)
Lo	Long Island Nature Reserve (Coveny & McDougall 1990)
Ma	Marramarra National Park (Benson et al. 1989, NPWS n.d., McDougall 1993)
Mu	Muogamarra Nature Reserve (Thomas & Benson 1985b)
Be	Berowra Valley Bushland Park (Smith & Smith 1990)
KC	Ku-ring-gai Chase National Park (Thomas & Benson 1985a)
Ba	Barrenjoey (McDougall 1994)
An	Angophora Reserve and Hudson Park (Smith & Smith 1993)
Ka	Katandra Bushland Sanctuary (Coveny, I.)
Gn	Garigal National Park: Deep Creek Catchment (Sheringham & Sanders 1993)
Gd	Garigal National Park: Davidson Park (McDougall & Conroy 1988–90)
Cu	Cumberland State Forest (Forestry Commission of NSW 1984)
PH	Pennant Hills Park (Beecroft Cheltenham Civic Trust 1976)
DH	Dalrymple Hay Nature Reserve (Benson & Keith 1984a)
Da	Darling Mills State Forest (FC of NSW 1984)
LC	Lane Cove National Park (Clarke & Benson 1987)
Ma	Manly Dam Memorial Park (Benson 1981)
Wa	Wallumatta Nature Reserve (Benson & Keith 1984c)
SH	Sydney Harbour National Park: includes North Head, Dobroyd Head, Bradleys Head, Nielsen Park (Holland 1980, NPWS n.d., Horton 1986)
HB	Homebush Bay (Kachka 1993)
Wo	Wolli Creek Valley (Robinson 1987)
La	La Perouse (Armstrong et al. 1976)



Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Ferns and fern allies																									
Adiantaceae																									
<i>Adiantum aethiopicum</i>	Bd	BW	Li		Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu		DH	Da	LC		SH			Wo	La
<i>Adiantum formosum</i>		BW							KC																
<i>Adiantum hispidulum</i>	Bd	BW					Mu	Be				Ka	Gn		Cu			Da	LC						
<i>Adiantum silvaticum</i>		BW							KC										LC						
Aspidiaceae																									
<i>Polystichum australiense</i>	Bd							Be																	
Aspleniaceae																									
<i>Asplenium australasicum</i>		BW							KC			Ka										SH		Wo	La
<i>Asplenium difforme</i>			Li							Ba															
<i>Asplenium flabellifolium</i>	Bd	BW	Li		Lo	Mm	Mu	Be	KC	Ba		Ka	Gn	Gd				Da	LC		SH			Wo	
Blechnaceae																									
<i>Blechnum ambiguum</i>		BW				Mm	Mu	Be	KC			Ka	Gn									SH			
<i>Blechnum camfieldii</i>		BW										Ka	Gn												
<i>Blechnum cartilagineum</i>	Bd	BW			Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu		DH	Da	LC		SH			Wo	La
<i>Blechnum indicum</i>													Gn												
<i>Blechnum nudum</i>		BW					Mu	Be						Gd					LC		SH				
<i>Blechnum wattsi</i>		BW																							
<i>Doodia aspera</i>	Bd	BW				Mm	Mu	Be	KC	Ba	An				Cu			Da	LC						
<i>Doodia caudata</i>		BW						Be	KC	Ba			Gn					Da			SH				
Cyatheaceae																									
<i>Calochlaena dubia</i>	Bd	BW			Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu		DH	Da	LC	Ma	Wa	SH		Wo	La
<i>Cyathea australis</i>		BW			Lo	Mm	Mu	Be	KC		An	Ka	Gn	Gd			DH			Ma				Wo	La
Davalliaceae																									
<i>Arthropteris tenella</i>									KC																
<i>Davallia pyxidata</i>	Bd	BW	Li		Lo	Mm	Mu	Be	KC			Ka	Gn							Ma		SH			
Dennstaedtiaceae																									
<i>Dennstaedtia davallioides</i>																			LC						
<i>Histiopteris incisa</i>	Bd	BW	Li			Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu			Da	LC	Ma		SH		Wo	La

<i>Hypolepis muelleri</i> <i>Hypolepis punctata</i> <i>Pteridium esculentum</i>	BW		Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu		LC	Ma	SH	Wo			
	BW																			
	BW	Li																		
	Bd		Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	DH	Da	LC	Ma	Wa	SH	Wo
Dryopteridaceae																				
<i>Lastreopsis decomposita</i>	BW																			
<i>Lastreopsis microspora</i>	BW		Mm	Mu		KC														
Gleicheniaceae																				
<i>Dicranopteris linearis</i>			Mm	Mu																
<i>Gleichenia dicarpa</i>	Bd	BW	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		LC	Ma		SH	La		
<i>Gleichenia microphylla</i>	BW	BW	Lo	Mm	Mu	Be	KC			Ka	Gn	Gd					SH			
<i>Gleichenia rupestris</i>	Bd	BW		Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd					SH	La		
<i>Sticherus flabellatus</i>	BW		Lo	Mm	Mu	Be	KC			Ka	Gn			Da	LC		SH			
Grammitidaceae																				
<i>Grammitis billardieri</i>	BW				Be				Ka											
Hymenophyllaceae																				
<i>Hymenophyllum cupressiforme</i>	BW		Mm	Mu	Be	KC			Ka	Gn	Gd			Da	LC					
Lindsaeaceae																				
<i>Lindsaea dimorpha</i>																				
<i>Lindsaea linearis</i>	Bd	BW	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu		Ma	Ma	Wa	SH	La	
<i>Lindsaea microphylla</i>	BW		Lo	Mm	Mu	Be	KC	Ba		Ka	Gn	Gd	Cu	DH	Da	LC		SH		
Lycopodiaceae																				
<i>Lycopodium cernuum</i>	BW																			
<i>Lycopodium deuterodensum</i>	BW			Mu		KC					Gd									
<i>Lycopodium laterale</i>	BW			Mm	Mu	Be					Gd				LC					
Osmundaceae																				
<i>Todea barbara</i>	Bd	BW	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		Da	Ma		SH	Wo		
Polypodiaceae																				
<i>Dictmia brownii</i>	BW				Be															
<i>Microsorium scandens</i>	BW																			
<i>Platyserium bifurcatum</i>	Bd	BW	Lo	Mm	Be		Ba		Ka				Cu				SH			
<i>Pyrosia rupestris</i>	BW		Lo	Mm	Mu	Be	KC		Ka	Gn	Gd	Cu		LC			SH			

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Psilotaceae																									
<i>Psilotum nudum</i>		BW	Li				Mu	Be	KC	Ba	An	Ka	Gn	'Gd					LC	Ma				Wo	
<i>Pteris trunctata</i>		BW										Ka	Gn												
<i>Pteris tremula</i>								Be				Ka			Cu										
<i>Pteris umbrosa</i>									KC																
Schizaeaceae																									
<i>Schizaea bifida</i>							Mu	Be	KC			Ka	Gn	Gd				Da	LC			SH			
<i>Schizaea dichotoma</i>		BW					Mu	Be					Gn	Gd											
<i>Schizaea rupestris</i>		BW				Mm	Mu					Ka	Gn	Gd											
Selaginellaceae																									
<i>Selaginella uliginosa</i>	Bd	BW									An	Ka	Gn	Gd						Ma		SH			La
Sinopteridaceae																									
<i>Cheilanthes distans</i>		BW			Lo		Mu	Be				Ka													
<i>Cheilanthes sieberi</i>	Bd	BW	Li		Lo		Mm	Be	KC	Ba			Gn	Gd				Da	LC		Wa	SH	HB		
<i>Pellaea falcata</i>		BW			Lo		Mm	Be	KC	Ba					Cu				LC			SH			
Thelypteridaceae																									
<i>Christella dentata</i>	Bd													Gd								SH			
Cycads																									
Zamiaceae																									
<i>Macrozamia communis</i>	Bd	BW	Li		Lo				KC		An	Ka	Gn											Wo	La
Conifers																									
Cupressaceae																									
<i>Callitris rhomboidea</i>								Be	KC					Gd											
Podocarpaceae																									
<i>Podocarpus spinulosus</i>	Bd	BW	Li					Be					Gn	Gd				Da	LC			SH		Wo	

Dicotyledons

Acanthaceae

- Brunoniella australis*
Brunoniella pumilio
Pseuderanthemum variabile

HB

LC
LC
Wa

Aizoaceae

- Carpobrotus glaucescens*
Tetragonia tetragonoides

La

SH
SH

HB

SH

Wo

Amaranthaceae

- Alternanthera denticulata*

Apiaceae

- Actinotus helianthi*
Actinotus minor
Apium prostratum
Centella asiatica
Daucus glochidiatus
Hydrocotyle geraniifolia
Hydrocotyle laxiflora
Hydrocotyle peduncularis
Hydrocotyle tripartita
Hydrocotyle verticillata
Platysace clelandii
Platysace ericoides
Platysace lanceolata
Platysace linearifolia
Platysace stephensonii
Trachymene incisa
Xanthosia dissecta
Xanthosia pilosa
Xanthosia tridentata

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

La

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Araliaceae																									
<i>Astrotiricha crassifolia</i>		BW																							
<i>Astrotiricha floccosa</i>		BW			Lo	Mm	Mu	Be	KC		An	Ka	Gn	Gd				Da	LC			SH			
<i>Astrotiricha latifolia</i>	Bd	BW		Sp		Mm													LC						
<i>Polyscias murrayi</i>		BW																							
<i>Polyscias sambucifolia</i>	Bd	BW						Be	KC		An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Wa		SH	HB	Wo	La
Asclepiadaceae																									
<i>Marsdenia rostrata</i>							Mu		KC	Ba	An										SH				
<i>Marsdenia suaveolens</i>	Bd	BW			Lo	Mm	Mu	Be		Ba		Ka	Gn	Gd		PH		Da	LC		SH				
<i>Tylophora barbata</i>						Mm		Be				Ka			Cu		DH		LC				HB		
Asteraceae																									
<i>Actites megalocarpa</i>																									
<i>Brachycome angustifolia</i>				Sp					KC		An			Gd			DH		LC		Wa				
<i>Brachycome multifida</i>						Mm													LC						
<i>Bracteantha bracteata</i>						Mm																			
<i>Calotis dentex</i>																									
<i>Calotis lappulacea</i>																									
<i>Cassinia aculeata</i>		BW	Li													PH	DH			Wa			HB		
<i>Cassinia arcuata</i>																							HB		
<i>Cassinia aureonitens</i>	Bd					Mm								Gd											
<i>Cassinia compacta</i>						Mm	Mu																		
<i>Cassinia denticulata</i>	Bd	BW			Lo		Mu	Be	KC					Gd		PH						SH			
<i>Cassinia longifolia</i>		BW						Be																	
<i>Cassinia quinquefaria</i>	Bd																								
<i>Cassinia uncata</i>										Ba	An	Ka													
<i>Chrysocephalum apiculatum</i>							Mu											Da							
<i>Cotula australis</i>																									
<i>Epaltes australis</i>	Bd	BW			Lo			Be												Ma		SH	HB	La	La
<i>Helichysum elatum</i>		BW							KC			Ka		Gd		PH			LC			SH	HB		
<i>Helichysum scorpioides</i>																									
<i>Lagenifera stipitata</i>																					Wa	SH			
<i>Leptinella longipes</i>	BW				Lo			Be			An	Ka	Gn			PH	DH					SH		Wo	La
<i>Olearia microphylla</i>																									
<i>Olearia tomentosa</i>	Bd	BW					Mu	Be	KC	Ba		Ka	Gn	Gd	Cu	PH			LC			SH	HB	Wo	La

<i>Olearia viscidula</i>	Bd	BW	Li	Sp	Mm	Mu	Be	KC	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Wa	SH	HB	Wo	La
<i>Ozothamnus diosmifolius</i>																						
<i>Pseudognaphalium luteoalbum</i>																						
<i>Senecio amygdalifolius</i>	Bd				Mm	Mu		KC													HB	
<i>Senecio bipinnatisectus</i>																						
<i>Senecio glomeratus</i>	Bd	BW					Be	KC			Gn		Cu				Ma	Wa	SH	HB	La	
<i>Senecio hispidulus</i>													Cu				LC		SH	HB	Wo	La
<i>Senecio lautus</i>	Bd					Mu	Be	KC					Cu						SH	HB	Wo	La
<i>Senecio linearifolius</i>							Be	KC														
<i>Senecio minimus</i>	Bd	BW	Li				Be	KC					Cu									
<i>Senecio quadridentatus</i>							Be													HB		
<i>Senecio vagus</i>																						
<i>Senecio subsp. eglandulosus</i>	Bd								Ba		Gn											
<i>Sigesbeckia orientalis</i>					Mm	Mu	Be	KC			Gn		Cu		DH							
<i>Solenogyne belliioides</i>																	LC				HB	HB
<i>Vernonia cinerea</i> var. <i>cinerea</i>	Bd				Mm			KC	An	Ka					DH							
<i>Vittadinia muelleri</i>																						
Avicenniaceae																						
<i>Avicennia marina</i>																						
<i>subsp. australasica</i>				Sp	Lo	Mm	Mu	Be	KC			Gd					LC			HB	Wo	La
<i>Bauera microphylla</i>																						
<i>Bauera rubioides</i>	Bd	BW			Mm	Mu	Be	KC		Ka	Gn	Gd		PH			LC	Ma	SH			
Bignoniaceae																						
<i>Pandorea pandorana</i>	Bd	BW	Li	Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	PH	DH	Da	LC	Wa	SH	HB	Wo
Callitrichaceae																						
<i>Callitriche muelleri</i>							Be															
Campanulaceae																						
<i>Wahlenbergia communis</i>																						
<i>Wahlenbergia gracilis</i>	Bd			Sp	Lo	Mm	Be		Ba	An	Ka	Gn	Cu						SH	HB	Wo	La
<i>Wahlenbergia stricta</i>																						
<i>subsp. stricta</i>			Li		Mm										DH		LC					
Caryophyllaceae																						
<i>Stellaria flaccida</i>					Mm																	

<i>Cuscuta australis</i>	Bd	BW	Li	Mm	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Cu	DH	LC	Wa	SH	HB	La
<i>Dichondra repens</i>	Bd		Lo	Lo	Mm	Mu	Be	KC	KC									HB	
<i>Polymeria calycina</i>						Mu												HB	
<i>Wilsonia backhousei</i>																		HB	
Crassulaceae																			
<i>Crassula helmsii</i>	BW																		
<i>Crassula sieberiana</i>	Bd	BW	Li	Lo	Mm	Be	Be	KC	Ba	An	Ka				LC		SH	Wo	La
Cunoniaceae																			
<i>Callicoma serratifolia</i>																			
<i>Ceratopetalum apetalum</i>	Bd	BW		Mm	Mu	Be	Be	KC	KC		Ka	Gn	Gd	PH	Da	Ma	SH	Wo	
<i>Ceratopetalum gummiferum</i>		BW	Sp	Mm	Mu	Be	Be	KC	KC		Ka	Gn	Gd	PH	Da	Ma	SH	Wo	
<i>Schizomeria ovata</i>	Bd	BW		Mm	Mu			KC	KC		Ka	Gn			LC		SH	Wo	La
Dilleniaceae																			
<i>Hibbertia acicularis</i>	Bd	BW		Mm	Mu	Be	Be	KC	KC			Gn	Cu	DH	LC	Wa		HB	La
<i>Hibbertia aspera</i>	Bd	BW		Mm	Mu	Be	Be	KC	KC		Ka	Gn			LC			Wo	
<i>Hibbertia bracteata</i>				Mm	Mu														
<i>Hibbertia circumdans</i>	Bd	BW		Mm	Mu	Be	Be	KC	KC			Gn	Gd		LC	Ma	SH	Wo	
<i>Hibbertia cistiflora</i>	Bd	BW	Li	Mm	Mu	Be	Be	KC	KC	Ba		Gn	Gd	PH	Da		SH	Wo	
<i>Hibbertia dentata</i>				Mm	Mu	Be	Be	KC	KC	An	Ka	Gn	Gd	PH	LC		SH	Wo	
<i>Hibbertia diffusa</i>	Bd	BW	Lo	Mm	Mu	Be	Be	KC	KC	An	Ka	Gn	Gd	PH	LC	Ma	SH	Wo	
<i>Hibbertia empetrifolia</i>	Bd	BW	Li	Lo	Mm	Mu	Be	KC	KC	Ba	Ka	Gn	Gd	PH	Da	Ma	SH	La	
<i>Hibbertia fasciculata</i>	Bd	BW				Be	Be	KC	KC		Ka	Gn	Gd	PH		Ma	SH	La	
<i>Hibbertia linearis</i>		BW			Mu	Be	Be	KC	KC		Ka	Gn	Gd		LC	Ma	SH	La	
<i>Hibbertia monogyna</i>	Bd				Mu			KC	KC										
<i>Hibbertia nitida</i>												Gn	Gd						
<i>Hibbertia obtusifolia</i>	Bd	BW	Li	Sp	Mu	Be	Be			An				Da					
<i>Hibbertia riparia</i>	Bd					Be	Be	KC										HB	
<i>Hibbertia rufa</i>		BW															SH	Wo	La
<i>Hibbertia scandens</i>	Bd	BW	Li			Be	Be	KC	Ba			Gn	Gd	DH	LC		SH	Wo	La
<i>Hibbertia serpyllifolia</i>												Gn							
Droseraceae																			
<i>Drosera auriculata</i>	Bd	BW		Mm	Mu			KC			Ka	Gn	Gd	PH	Da	Ma	SH	Wo	
<i>Drosera binata</i>	Bd	BW			Mu	Be	Be	KC	KC	An	Ka	Gn	Gd			Ma	SH	Wo	
<i>Drosera peltata</i>		BW		Mm	Mu	Be	Be	KC	KC		Ka	Gn	Gd	Da		Ma	SH		La
<i>Drosera pygmaea</i>		BW		Mm	Mu	Be	Be	KC	KC								SH		La
<i>Drosera spatulata</i>	Bd	BW		Lo	Mm	Mu	Be	KC	KC	An	Ka	Gn	Gd	PH		Ma	SH		La

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Ebenaceae																									
<i>Diospyros australis</i>	Bd									Ba															
Elaeocarpaceae																									
<i>Elaeocarpus reticulatus</i>	Bd	BW		Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		PH		Da	LC	Ma	Wa	SH		Wo	La
<i>Sloanea australis</i>												Ka										SH			
Elatinaceae																									
<i>Elatine gratioides</i>													Gn												La
Epacridaceae																									
<i>Acrotriche divaricata</i>	Bd	BW						Be	KC			Ka	Gn	Gd			DH								
<i>Astroloma humifusum</i>	Bd							Be										Da					SH	HB	Wo
<i>Astroloma pinifolium</i>	Bd	BW							KC														SH		La
<i>Brachyoloma daphnoides</i>	Bd	BW			Lo	Mm	Mu	Be	KC				Gn	Gd		PH			LC	Ma			SH		La
<i>Dracophyllum secundum</i>		BW		Sp	Lo	Mm	Mu	Be	KC				Gn	Gd		PH			LC				SH		La
<i>Epacris crassifolia</i>		BW						Be	KC				Gn	Gd					LC	Ma			SH		La
<i>Epacris longiflora</i>	Bd	BW		Sp		Mm	Mu	Be	KC	Ba		Ka	Gn	Gd		PH			LC	Ma			SH		La
<i>Epacris microphylla</i>	Bd	BW						Be	KC		An		Gn	Gd		PH			LC	Ma			SH		La
<i>Epacris obtusifolia</i>		BW						Be	KC			Ka	Gn	Gd					LC	Ma			SH		La
<i>Epacris pulchella</i>	Bd	BW		Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		PH		Da	LC	Ma	Wa		SH		Wo
<i>Epacris purpurascens</i>																									
var. <i>purpurascens</i>																									
<i>Epacris rigida</i>		BW					Mu	Be								PH									
<i>Leucopogon amplexicaulis</i>																PH									
<i>Leucopogon appressus</i>	Bd	BW					Mu	Be	KC			Ka	Gn	Gd		PH			LC	Ma			SH		Wo
<i>Leucopogon deformis</i>	Bd					Mm	Mu		KC				Gn	Gd											
<i>Leucopogon ericoides</i>	Bd	BW						Be	KC			Ka	Gn	Gd		PH			LC	Ma			SH		La
<i>Leucopogon esquamatius</i>	Bd	BW					Mu	Be	KC	Ba			Gn	Gd					LC	Ma			SH		La
<i>Leucopogon juniperinus</i>								Be											LC	Ma			SH		La
<i>Leucopogon lanceolatus</i>								Be	KC			Ka	Gn	Gd		PH			LC		Wa				Wo
<i>Leucopogon margarodes</i>		BW																							
<i>Leucopogon microphyllus</i>		BW						Be	KC			Ka	Gn	Gd		PH	DH	Da	LC				HB		Wo
<i>Leucopogon muticus</i>																									
<i>Leucopogon parviflorus</i>																									
<i>Leucopogon setiger</i>	Bd	BW						Be	KC	Ba			Gn	Gd		PH			LC	Ma			SH		

[illegible]

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Fabaceae-Faboideae																									
<i>Almaleea paludosa</i>		BW							KC																La
<i>Aotus ericoides</i>	Bd	BW					Mu	Be			An		Gn	Gd										Wo	La
<i>Bossiaea ensata</i>	Bd	BW						Be	KC		An		Gn									SH			La
<i>Bossiaea heterophylla</i>	Bd	BW	Li				Mm	Be	KC			Ka	Gn	Gd		PH		Da	LC	Ma		SH		Wo	La
<i>Bossiaea lenticularis</i>							Mm																		
<i>Bossiaea obtordata</i>		BW					Mm	Be	KC				Gn	Gd		PH		Da	LC		Wa				
<i>Bossiaea prostrata</i>																							HB		
<i>Bossiaea rhombifolia</i>								Be																	La
<i>Bossiaea scolopendria</i>	Bd	BW					Mm	Be	KC				Gn	Gd		PH			LC	Ma		SH			
<i>Bossiaea stephensonii</i>		BW					Mm																		
<i>Daviesia alata</i>		BW							KC																
<i>Daviesia corymbosa</i>	Bd						Mm	Be																	
<i>Daviesia ulicifolia</i>	Bd	BW					Mu	Be							Cu										
<i>Desmodium brachypodium</i>	Bd																								
<i>Desmodium rhytidophyllum</i>		BW			Lo		Mu		KC		An		Gn				DH								
<i>Desmodium varians</i>		BW			Lo		Mu	Be	KC	Ba		Ka	Gn		Cu										
<i>Dillwynia acicularis</i>							Mu																		
<i>Dillwynia floribunda</i>																									La
<i>Dillwynia floribunda</i> var. <i>floribunda</i>	Bd	BW		Sp			Mm	Be	KC			Ka	Gn	Gd						Ma		SH			
<i>Dillwynia floribunda</i> var. <i>teretifolia</i>																									La
<i>Dillwynia glaberrima</i>	Bd						Mm	Be	KC				Gn	Gd		PH						SH			
<i>Dillwynia parvifolia</i>																									
<i>Dillwynia retorta</i>	Bd	BW	Li				Mm	Be	KC		An	Ka	Gn	Gd	Cu	PH		Da	LC	Ma	Wa	SH			La
<i>Dillwynia sericea</i> (<i>D. rudis</i>)	Bd	BW					Mm	Be					Gn	Gd					LC						
<i>Glycine clandestina</i>																									
species complex		BW		Sp	Lo		Mm	Be	KC	Ba	An	Ka	Gn			PH			LC		Wa	SH	HB		La
<i>Glycine microphylla</i>																									
<i>Glycine tabacina</i>																									
species complex																									
<i>Gompholobium glabratum</i>	Bd							Be	KC		An			Gd		PH	DH					SH	HB		La
<i>Gompholobium grandiflorum</i>	Bd	BW					Mm	Be	KC				Gd			PH		Da	LC	Ma					
<i>Gompholobium latifolium</i>		BW					Mm	Be	KC			Ka	Gn	Gd		PH			LC			SH			
<i>Gompholobium minus</i>	Bd	BW		Sp	Lo		Mm	Be	KC		An	Ka	Gn	Gd		PH			LC	Ma		SH			HB
<i>Gompholobium pinnatum</i>																			LC						

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Lamiaceae																									
<i>Hemigenia purpurea</i>		BW					Mu	Be	KC				Gn	Gd		PH			LC	Ma		SH			
<i>Lycopus australis</i>							Mu																		
<i>Plectranthus graveolens</i>			Sp																						
<i>Plectranthus parviflorus</i>	Bd	BW	Sp	Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	DH						SH			
<i>Prostanthera denticulata</i>									KC	Ba		Ka	Gn												
<i>Prostanthera incana</i>							Mu																		
<i>Prostanthera linearis</i>	Bd	BW				Mm	Mu	Be	KC				Gn	Gd					LC						
<i>Prostanthera ovalifolia</i> s. lat.					Lo	Mm	Mu	Be																	
<i>Prostanthera rhombea</i>	Bd	BW				Mm																			
<i>Westringia fruticosa</i>	Bd	BW	Li							Ba												SH			La
Lauraceae																									
<i>Cassytha glabella</i>	Bd		Li		Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		PH			LC			SH	HB		La
<i>Cassytha pubescens</i>		BW	Li		Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		PH			LC	Ma	Wa	SH	HB		La
<i>Cryptocarya glaucescens</i>		BW										Ka													
<i>Endiandra sieberi</i>	Bd	BW	Li		Lo				KC			Ka	Gn									SH			La
Lentibulariaceae																									
<i>Utricularia biloba</i>		BW						Be												Ma		SH			La
<i>Utricularia dichotoma</i>		BW						Be	KC																La
<i>Utricularia lateriflora</i>	Bd	BW										Ka													La
<i>Utricularia uliginosa</i>		BW																							La
Lobeliaceae																									
<i>Lobelia alata</i>	Bd	BW	Li		Lo	Mm	Mu		KC	Ba	An			Gd					LC	Ma		SH		Wo	La
<i>Lobelia dentata</i>		BW						Be	KC			Ka	Gn	Gd				Da		Ma		SH			
<i>Lobelia gibbosa</i>		BW										Ka				PH									
<i>Lobelia gracilis</i>																									
<i>Pratia purpurascens</i>	Bd	BW	Sp	Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC		Wa	SH	HB	Wo	Wo
Loganiaceae																									
<i>Logania albiflora</i>	Bd	BW	Sp	Sp	Lo	Mm	Mu	Be	KC			Ka	Gn	Gd		PH				Ma		SH		Wo	
<i>Logania pusilla</i>							Mu					Ka													
<i>Mitrasacme polymorpha</i>	Bd	BW			Lo	Mm	Mu	Be	KC		An	Ka	Gn	Gd				Da	LC	Ma		SH		La	

Loranthaceae									
<i>Anyema congener</i>									Wo
<i>Anyema gaudichaudii</i>									
<i>Anyema miquelii</i>									
<i>Anyema pendulum</i>	BW								
<i>subsp. pendulum</i>	Bd								
<i>Dendrophthoe vitellina</i>	Bd								
<i>Muellerina celastroides</i>									
<i>Muellerina eucalyptoides</i>	Bd								
Lythraceae									
<i>Lythrum hyssopifolia</i>									HB
Malvaceae									
<i>Hibiscus diversifolius</i>									
<i>Howittia trilocularis</i>	Bd	BW							
Meliaceae									
<i>Melia azedarach</i>									
<i>Synoum glandulosum</i>	Bd	BW							
<i>Toona ciliata (Toona australis)</i>									
Menispermaceae									
<i>Sarcopetalum haneyanum</i>	Bd	BW							
<i>Stephania japonica</i>									
<i>var. discolor</i>	Bd	BW							
Menyanthaceae									
<i>Villarsia exaltata</i>									
Monimiaceae									
<i>Doryphora sassafras</i>									
<i>Palmeria scandens</i>									
<i>Wilkiea huegelliana</i>	Bd								
Moraceae									
<i>Ficus coronata</i>	Bd	BW							
<i>Ficus rubiginosa</i>	Bd	BW							
<i>Ficus superba</i> <i>var. henneana</i>									
<i>Malaisia scandens</i>	Bd								

[illegible]

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
<i>Eucalyptus umbra</i>	Bd	BW		Sp	Lo		Mu		KC		An	Ka	Gn	Gd				Da		Ma		SH			
<i>Kunzea ambigua</i>	Bd	BW	Li	Sp	Lo		Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH		Da	LC	Ma	Wa	SH	HB	Wo	La
<i>Kunzea capitata</i>	BW					Mm	Mu	Be	KC				Gn	Gd					LC	Ma		SH			
<i>Kunzea rupestris</i>						Mm			KC																
<i>Leptospermum arachnoides</i>		BW				Mm	Mu	Be	KC				Gn	Gd		PH			LC	Ma		SH			La
<i>Leptospermum deanei</i>						Mm			KC					Gd		PH									
<i>Leptospermum grandifolium</i>		BW				Mm		Be					Gn	Gd						Ma					
<i>Leptospermum juniperinum</i>	Bd	BW					Mu		KC		An	Ka	Gn	Gd						Ma		SH		La	
<i>Leptospermum laevigatum</i>	Bd	BW	Li							Ba			Gn	Gd					LC			SH		La	
<i>Leptospermum parvifolium</i>	BW					Mm			KC				Gd							Ma					
<i>Leptospermum polygalifolium</i>	Bd	BW				Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		PH		Da	LC	Ma		SH		Wo	La
<i>Leptospermum scoparium</i>	Bd	BW				Mm			KC																
<i>Leptospermum squarrosum</i>	Bd	BW				Mm	Mu	Be	KC	Ba		Ka	Gn	Gd					LC	Ma		SH		La	
<i>Leptospermum trinervium</i>	Bd	BW	Li	Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		PH		Da	LC	Ma	Wa	SH		Wo	La
<i>Melaleuca armillaris</i>																						SH			La
<i>Melaleuca biconvexa</i>																									
<i>Melaleuca deanei</i>	Bd	BW						Be					Gd								Wa				
<i>Melaleuca decora</i>					Lo													Da						Wo	
<i>Melaleuca ericifolia</i>										Ba												SH			
<i>Melaleuca hypericifolia</i>							Mu	Be					Gn											Wo	La
<i>Melaleuca linariifolia</i>	Bd														PH							SH	HB	Wo	La
<i>Melaleuca nodosa</i>																						SH			
<i>Melaleuca quinquenervia</i>					Lo																				La
<i>Melaleuca squamea</i>	Bd	BW											Gn	Gd		PH					Wa		HB	Wo	La
<i>Melaleuca staphelioides</i>	Bd																							Wo	La
<i>Melaleuca thymifolia</i>																									
<i>Micromyrtus blakelyi</i>	Bd					Mm	Mu							Gd					LC	Ma					
<i>Micromyrtus ciliata</i>	Bd					Mm	Mu	Be	KC																
<i>Micromyrtus rubescens</i>	Bd					Mm			KC																
<i>Rhodomyrtus psidioides</i>										Ba															
<i>Syncarpia glomulifera</i>	Bd	BW			Lo	Mm	Mu	Be	KC		An	Ka		Gd	Cu	PH	DH	Da	LC		Wa	SH	HB	Wo	
<i>Syzgium australe</i>																						SH			
<i>Syzgium oleosum</i>	Bd	BW								Ba			Gn											Wo	
<i>Syzgium paniculatum</i>																									
<i>Tristania neriifolia</i>	Bd	BW					Mu	Be					Gn	Gd		PH								Wo	
<i>Tristaniopsis collina</i>					Lo			Be	KC	Ba			Gn	Gd								SH		Wo	
<i>Tristaniopsis laurina</i>	Bd	BW		Sp		Mm	Mu	Be	KC			Ka	Gn	Gd		PH		Da	LC					Wo	

	BW	Mm	Mu	Be	KC	Ka	Gn	Gd	PH	Da	LC	Ma	SH	Wo
<i>Grevillea buxifolia</i>														
subsp. <i>buxifolia</i>													SH	
<i>Grevillea buxifolia</i>														
subsp. <i>sphacelata</i>														
<i>Grevillea caleyi</i>														
<i>Grevillea linearifolia</i>	Bd	BW		Be	KC		An	Gd	PH	Da	LC	Ma	SH	HB
<i>Grevillea linearifolia</i>														
(<i>G. parviflora</i>)														
<i>Grevillea mucronulata</i>		Mm												
<i>Grevillea sericea</i>	BW	Mm	Mu	Be	KC		An	Gn	PH	Da	LC	Ma	Wa	Wo
<i>Grevillea shiressii</i>	BW													
<i>Grevillea speciosa</i>	BW	Mm		Be	KC		An	Gd	PH	Da	LC	Ma	SH	
<i>Hakea bakeriana</i>		Mm		Be							LC			
<i>Hakea dactyloides</i>	Bd	BW	Lo	Mu	KC		An	Gd	PH		LC	Ma	SH	Wo
<i>Hakea gibbosa</i>	Bd	BW	Mm	Mu	KC	Ba	An	Gd	PH		LC	Ma	SH	La
<i>Hakea propinqua</i>	BW	Mm	Mu	Be	KC		An	Gd			LC			La
<i>Hakea salicifolia</i>				Be			An	Gd		Da	LC			
<i>Hakea sericea</i>	Bd	BW	Mu	Be	KC	Ba	An	Gd	Cu	Da	LC	Ma	Wa	Wo
<i>Hakea teretifolia</i>	Bd	BW	Mm	Mu	KC	Ba	An	Gd	PH	Da	LC	Ma	SH	La
<i>Isopogon anemonifolius</i>	Bd	BW	Mm	Mu	KC		An	Gd	Cu	Da	LC			La
<i>Isopogon anethifolius</i>	Bd	BW	Mu	Be	KC	Ba		Gd	PH	Da	LC	Ma	SH	Wo
<i>Lambertia formosa</i>	Bd	BW	Mm	Be	KC		An	Gd	PH	Da	LC	Ma	SH	La
<i>Lomatia myricoides</i>	BW	Mm	Mu	Be	KC			Gd	PH		LC			
<i>Lomatia silaifolia</i>	Bd	BW	Lo	Mu	KC	Ba	An	Gd	Cu	Da	LC	Ma	Wa	Wo
<i>Persoonia hirsuta</i>			Mu											
subsp. <i>hirsuta</i>														
<i>Persoonia isophylla</i>	Bd	BW			KC									La
<i>Persoonia lanceolata</i>	Bd	BW	Mm	Be	KC		Ka	Gn	Gd		LC	Ma	Wa	SH
<i>Persoonia laurina</i>														
subsp. <i>laurina</i>														
<i>Persoonia levis</i>	Bd	BW	Lo	Mu	KC		An	Gd	PH	Da	LC	Ma	Wa	Wo
<i>Persoonia linearis</i>	Bd	BW	Lo	Mu	KC		An	Gd	Cu	DH	LC	Ma	Wa	Wo
<i>Persoonia mollis</i> subsp. <i>mollis</i>														
<i>Persoonia pinifolia</i>														
<i>Petrophile pulchella</i>	Bd	BW	Mm	Be	KC		An	Gd	PH		LC	Ma	SH	La
<i>Petrophile sessilis</i>	Bd	BW	Mm	Be	KC			Gd	PH	Da	LC	Ma		
<i>Stenocarpus salignus</i>		BW	Mm	Be	KC		Ka	Gn	PH		LC	Ma	SH	
<i>Symphionema paludosum</i>		BW												
<i>Telopea speciosissima</i>	Bd	BW	Mu	Be	KC		Ka	Gd	PH	Da	LC	Ma	SH	Wo
<i>Xylomelum pyrifforme</i>	Bd	BW	Mm	Be	KC		An	Gd	PH	Da	LC	Ma	Wa	La

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Ranunculaceae																									
<i>Clematis aristata</i>	Bd	BW			Lo	Mm	Mu	Be	KC		An	Ka	Gn	Gd	Cu	PH	DH	Da	LC			SH	HB		
<i>Clematis glycinoides</i>																									
var. <i>glycinoides</i>											An				Cu	PH	DH		LC		Wa	SH	HB	Wo	
<i>Ranunculus inundatus</i>													Gn	Gd											
<i>Ranunculus plebeius</i>																									
Rhamnaceae																									
<i>Alphitonia excelsa</i>	BW					Mm	Mu		KC			Ka	Gn	Gd								SH			La
<i>Cryptandra amara</i> var. <i>amara</i>						Mm	Mu	Be		Ba			Gn	Gd								SH			
<i>Cryptandra ericoides</i>	BW								KC				Gn	Gd								SH			
<i>Pomaderris aspera</i>								Be								PH									
<i>Pomaderris discolor</i>						Mm		Be											LC					Wo	
<i>Pomaderris elliptica</i>	BW			Sp				Be					Gn	Gd		PH				Ma		SH			
<i>Pomaderris ferruginea</i>	Bd	BW				Mm			KC				Gn	Gd	Cu							SH	HB		
<i>Pomaderris intermedia</i>	BW	Li			Lo	Mm	Mu	Be					Gn	Gd								SH	HB	Wo	
<i>Pomaderris lanigera</i>	Bd								KC	Ba	An	Ka	Gn										HB		
<i>Pomaderris ligustrina</i>	BW																								
Rosaceae																									
<i>Rubus hillii</i>	Bd	BW				Mm	Mu		KC		An		Gn									SH			
<i>Rubus parvifolius</i>		BW	Li			Mm				Ba							DH								
<i>Rubus rostrifolius</i>	Bd					Mm			KC						Cu										
Rubiaceae																									
<i>Canthium coprosmoides</i>	BW								KC			Ka													
<i>Coprosma quadrifida</i>		BW						Be																	
<i>Galium binitolium</i>	BW							Be	KC			Ka			Cu			Da							
<i>Galium propinquum</i>						Mm																			
<i>Morinda jasminoides</i>	Bd	BW		Sp			Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH		Da				SH			
<i>Opercularia aspera</i>	Bd	BW			Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu			Da	LC	Ma		SH	HB	Wo	La
<i>Opercularia diphylla</i>		BW							KC				Gn	Gd								SH	HB		
<i>Opercularia hispida</i>					Lo		Mu		KC																
<i>Opercularia varia</i>	BW						Mu	Be	KC			Ka	Gn					Da	LC	Ma		SH	HB		La
<i>Pomax umbellata</i>	Bd	BW			Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu			Da	LC	Ma	Wa	SH	HB	Wo	La
<i>Psychotria loniceroides</i>	Bd								KC				Gn					Da	LC	Ma		SH	HB		La

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Sambucaceae																									
<i>Sambucus gaudichaudiana</i>								Be																	
Santalaceae																									
<i>Exocarpos cupressiformis</i>	Bd	BW	Li	Sp	Lo	Mm	Mu	KC			An	Ka			Cu		DH	Da	LC	Wa	SH	HB	Wo	La	
<i>Exocarpos strictus</i>							Be																		
<i>Leptomeria acida</i>	BW				Lo		Mu	KC				Ka	Gn			PH			LC						
Sapindaceae																									
<i>Alectryon subcinereus</i>		BW																							
<i>Cupaniopsis anacardioides</i>																						SH			
<i>Dodonaea camfieldii</i>		BW																							
<i>Dodonaea pinnata</i>		BW				Mm	Mu	KC					Gn												
<i>Dodonaea triquetra</i>	Bd	BW	Li			Mm	Mu	Be	KC	Ba	An	Ka	Gn		Cu	PH	DH		LC	Ma	Wa	SH	HB	Wo	La
<i>Guioa semiglauc</i>	Bd	BW								Ba															
Scrophulariaceae																									
<i>Veronica calycina</i>		BW				Mm	Mu	Be			An				Gd		DH	Da	LC	Wa	SH	SH	HB	Wo	
<i>Veronica plebeia</i>																									
Solanaceae																									
<i>Duboisia myoporoides</i>	Bd	BW				Mm							Gn												
<i>Solanum americanum</i>																									
<i>S. nodiflorum</i>		BW	Li			Mm		Be		Ba	An	Ka			Cu	PH									La
<i>Solanum campanulatum</i>		BW					Mu		KC																
<i>Solanum opacum</i>																									
<i>S. nigrum</i>								Be					Gn									SH			La
<i>Solanum prinophyllum</i>	BW					Mm	Mu	Be	KC		An	Ka			Cu										
<i>Solanum pungetum</i>	BW					Mm									Cu										
Stackhousiaceae																									
<i>Stackhousia monogyna</i>	BW												Gn												La
<i>Stackhousia nuda</i>	BW								KC			Ka	Gn			PH							HB		
<i>Stackhousia viminea</i>	BW					Mm	Mu	Be	KC				Gd						LC	Ma					

Sterculiaceae

<i>Brachychiton populneus</i>	Bd	BW	Sp	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	PH	Da	Ma	Wa	SH	HB	La
<i>Lasiopetalum ferrugineum</i>	Bd	BW	Sp	Mm	Mu	Be	KC	Ba											
<i>Lasiopetalum macrophyllum</i>																			
<i>Lasiopetalum parviflorum</i>																			
<i>Lasiopetalum rufum</i>																			
<i>Rulingia dasyphylla</i>																			
<i>Rulingia hermanniifolia</i>	Bd																		La
<i>Seringia arborescens</i>																			

Stylidiaceae

<i>Stylidium graminifolium</i>																			La
<i>Stylidium lineare</i>	BW																		
<i>Stylidium productum</i>	BW	Li	Lo	Mm	Mu	Be	KC			Ka	Gn	Gd	PH	LC	Ma	Ma	SH		Wo

Symplocaceae

<i>Symplocos thwaitesii</i>	BW																		
-----------------------------	----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Thymelaeaceae

<i>Pimelea curviflora</i>																			
var. <i>curviflora</i>																			Ma
<i>Pimelea curviflora</i> var. <i>gracilis</i>																			
<i>Pimelea glauca</i>	BW																		
<i>Pimelea latifolia</i> subsp. <i>hirsuta</i>	BW																		
<i>Pimelea linifolia</i> subsp. <i>linifolia</i>	Bd																		
<i>Wikstroemia indica</i>	Bd		Li																
<i>Tetratheca ericifolia</i>	Bd																		
<i>Tetratheca glandulosa</i>																			
<i>Tetratheca shiressii</i>	BW																		
<i>Tetratheca thymifolia</i>	BW																		

Ulmaceae

<i>Trema aspera</i>	BW																		Wo
---------------------	----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	----

Urticaceae

<i>Urtica incisa</i>																			
----------------------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Verbenaceae

<i>Clerodendrum tomentosum</i>	Bd	BW	Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	DH	LC	SH	HB	
--------------------------------	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	--

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Violaceae																									
<i>Hybanthus monopetalus</i>	Bd	BW	Li	Sp	Lo	Mm	Mu	Be	KC							PH			LC						La
<i>Hybanthus vernonii</i> subsp. <i>vernonii</i>						Mm	Mu	Be				Ka	Gn	Gd											
<i>Hymenanchera dentata</i>								Be																	
<i>Viola betonicifolia</i>	Bd																								
<i>Viola hederacea</i>		BW				Mm	Mu	Be	KC		An	Ka	Gn	Gd	Cu	PH		Da	LC		SH	HB			La
<i>Viola sieberiana</i>							Mu						Gn	Gd											
Vitaceae																									
<i>Cayratia clematidea</i>	Bd	BW		Sp	Lo	Mm	Mu	Be	KC		An				Cu	PH							HB		
<i>Cissus antarctica</i>	Bd	BW	Li						KC	Ba											SH				
<i>Cissus hypoglauca</i>	Bd	BW		Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		PH			LC		SH				La
Winteraceae																									
<i>Tasmannia insipida</i>		BW							KC																
Monocotyledons																									
Agavaceae																									
<i>Dorothyanthus excelsa</i>		BW				Mm																			
Amaryllidaceae																									
<i>Crinum pedunculatum</i>			Li																						La
Anthericaceae (Liliaceae)																									
<i>Alania endlicheri</i>		BW							KC																
<i>Arthropodium milleflorum</i>		BW			Lo										Cu										
<i>Arthropodium minus</i>																									
<i>Caesia parviflora</i>		BW	Li	Sp		Mm		Be	KC		An	Ka	Gn	Gd		PH		DH	Da	LC				Wo	
<i>Caesia vittata</i>		BW						Be															HB		
<i>Laxmannia gracilis</i>		BW							KC					Gd											
<i>Sowerbaea juncea</i>	Bd	BW							KC					Gd											La
<i>Thysanotus juncifolius</i>	Bd	BW			Lo		Mu		KC		An		Gn	Gd		PH		Da			SH				
<i>Thysanotus tuberosus</i>		BW		Sp			Mu									PH		Da	LC	Ma		SH			La
<i>Tricoryne elatior</i>		BW			Lo		Mu																		
<i>Tricoryne simplex</i>								Be										Da	LC						

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
<i>Cyathochaeta diandra</i>	Bd	BW			Lo	Mm	Mu	Be	KC		An	Ka	Gn	Gd		PH		Da	LC	Ma	Wa	SH	HB		La
<i>Cyperus laevis</i>		BW							KC													SH			
<i>Cyperus polystachyos</i>		BW			Lo			Be	KC		An											SH	HB		La
<i>Cyperus sanguinolentus</i>																							HB		
<i>Cyperus tetraphyllus</i>																							HB		
<i>Eleocharis gracilis</i>							Mu						Gn		Cu										
<i>Eleocharis minuta</i>																									La
<i>Eleocharis sphacelata</i>																				Ma					La
<i>Fimbristylis dichotoma</i>		BW									An		Gn											Wo	
<i>Gahnia aspera</i>		BW				Mm	Mu	Be	KC	Ba															
<i>Gahnia clarkii</i>	Bd	BW			Lo	Mm	Mu	Be	KC		An	Ka	Gn	Gd								SH			
<i>Gahnia erythrocarpa</i>		BW	Li		Lo		Mu	Be	KC	Ba		Ka	Gn	Gd						Ma					
<i>Gahnia melanocarpa</i>	Bd	BW						Be	KC	Ba		Ka													
<i>Gahnia microstachya</i>								Be	KC																
<i>Gahnia radula</i>	BW																								
<i>Gahnia sieberiana</i>	BW					Mm	Mu	Be	KC			Ka	Gn	Gd	Cu			Da	LC			SH			La
<i>Gymnoschoenus</i>																									
<i>sphaerocephalus</i>		BW							KC																
<i>Isolepis cernua</i>																									La
<i>Isolepis inundata</i>		BW					Mu	Be				Ka		Gd					LC			SH	HB		La
<i>Isolepis nodosa</i>	Bd	BW	Li		Lo	Mm	Mu		KC	Ba	An		Gn	Gd					LC			SH	HB		La
<i>Lepidosperma concavum</i>		BW			Lo	Mm	Mu		KC	Ba		Ka		Gd					LC			SH	HB		La
<i>Lepidosperma elatius</i>	BW								KC	Ba												SH			La
<i>Lepidosperma filiforme</i>	BW						Mu	Be	KC				Gn	Gd						Ma					La
<i>Lepidosperma forsythii</i>																									
<i>Lepidosperma laterale</i>	Bd	BW	Li	Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH		Da	LC	Ma	Wa	SH	HB	Wo	La
<i>Lepidosperma limicola</i>		BW							KC									Da							
<i>Lepidosperma neesii</i>	BW						Mu					Ka	Gn	Gd						Ma		SH			La
<i>Lepidosperma urophorum</i>																									
<i>Lepidosperma viscidum</i>	Bd	BW					Mu	Be	KC				Gn	Gd					LC	Ma		SH			La
<i>Ptilothrix deusta</i>	Bd	BW					Mu	Be	KC		An		Gn	Gd				Da	LC	Ma		SH			
<i>Schoenoplectus validus</i>					Lo								Gn	Gd					LC				HB		La
<i>Schoenus apogon</i>													Gn	Gd					LC			SH	HB		La
<i>Schoenus brevifolius</i>	Bd	BW						Be	KC		An	Ka	Gn	Gd					LC	Ma		SH			La
<i>Schoenus ericetorum</i>	Bd	BW					Mu						Gn	Gd				Da	LC	Ma		SH			La
<i>Schoenus imberbis</i>		BW	Li	Sp	Lo	Mm	Mu	Be	KC			Ka	Gn	Gd					LC	Ma		SH			

[illegible]

[illegible]

Philydraceae

Philydrum lanuginosum

Phormiaceae (Liliaceae)

Blandfordia nobilis

Dianella caerulea var *caerulea*

Dianella caerulea var. *producta*

Dianella longifolia

var. *longifolia*

Dianella prunina

Dianella revoluta

Stypandra glauca

Thelionema caespitosum

Thelionema umbellatum

Poaceae

Agrostis aemula

Agrostis avenacea

Agrostis billardieri

Ancistrachne maidenii

Anisopogon avenaceus

Aristida benthamii

var. *spinulifera*

Aristida calycina var. *calycina*

Aristida ramosa var. *ramosa*

Aristida vagans

Aristida warburqii

Austrofestuca littoralis

Chionochloa pallida

Cymbopogon refractus

Cynodon dactylon

Danthonia linkii var. *linkii*

Danthonia longifolia

Danthonia pilosa var. *pilosa*

Danthonia setacea

Danthonia tenuior

Deyeuxia decipiens

Deyeuxia quadriseta

[illegible]

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
<i>Dichelachne crinita</i>						Mm														Ma		SH	HB		La
<i>Dichelachne micrantha</i>		BW		Sp		Mm		Be	KC		An	Ka					DH	Da	LC	Ma		SH	HB		La
<i>Dichelachne rara</i>		BW						Be				Ka			Cu		DH	Da					HB	Wo	
<i>Digitaria brownii</i>																									
<i>Digitaria didactyla</i>	Bd												Gn									SH			La
<i>Digitaria diffusa</i>								Be																	
<i>Digitaria parviflora</i>	Bd	BW			Lo		Mu	Be	KC		An	Ka	Gn		Cu						SH			Wo	
<i>Digitaria ramularis</i>								Be																	
<i>Echinopogon caespitosus</i>	Bd	BW			Lo	Mm	Mu	Be			An	Ka	Gn	Gd			DH		LC		Wa	SH	HB	Wo	
<i>Echinopogon ovatus</i>							Mu	Be	KC								DH				Wa		HB		
<i>Elymus scaber</i> var. <i>scaber</i>																									
<i>Entolasia marginata</i>	Bd	BW					Mu	Be	KC		An	Ka	Gn	Gd							Wa	SH	HB		La
<i>Entolasia stricta</i>	Bd	BW	Li		Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu			Da	LC	Ma	Wa	SH	HB		
<i>Eragrostis benthamii</i>				Sp				Be				Ka													
<i>Eragrostis brownii</i>	Bd	BW			Lo	Mm	Mu	Be	KC		An	Ka	Gn					Da		Ma		SH	HB	Wo	La
<i>Eragrostis leptostachya</i>					Lo		Mu	Be															HB		
<i>Hemarthria uncinata</i>																									
var. <i>uncinata</i>	Bd	BW																				SH			La
<i>Imperata cylindrica</i> var. <i>major</i>	Bd	BW		Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
<i>Isachne globosa</i>													Gn												
<i>Microlaena stipoides</i>																									
var. <i>stipoides</i>		BW			Lo		Mu	Be			An	Ka	Gn	Gd	Cu		DH	Da	LC	Ma	Wa		HB	Wo	La
<i>Oplismenus aemulus</i>		BW						Be			An											SH			
<i>Oplismenus imbecillis</i>	Bd	BW				Mm	Mu	Be	KC	Ba	An	Ka	Gn		Cu		DH	Da			Wa	SH			
<i>Panicum effusum</i>											An														
<i>Panicum obseptum</i>								Be			An														
<i>Panicum simile</i>	Bd	BW			Lo		Mu	Be	KC		An	Ka	Gn				DH		LC		Wa	SH	HB	Wo	La
<i>Paspalidium albobilosum</i>												Ka													
<i>Paspalidium aversum</i>											An														
<i>Paspalidium distans</i>	Bd	BW			Lo						An	Ka										SH	HB		La
<i>Paspalum distichum</i>																									
(<i>P. paspalodes</i>)																									
<i>Paspalum orbiculare</i>											An	Ka													
<i>Paspalum vaginatum</i>																									
(<i>P. distichum</i>)												Ka													
<i>Phragmites australis</i>	Bd	BW	Li			Mm	Mu	Be	KC				Gn	Gd					LC				HB	Wo	La

Botanical name	Bd	BW	Li	Sp	Lo	Ma	Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH	DH	Da	LC	Ma	Wa	SH	HB	Wo	La
Smilacaceae																									
<i>Smilax australis</i>	Bd	BW				Mm	Mu	Be	KC	Ba	An	Ka	Gn						LC				HB		
<i>Smilax glycyphylla</i>	Bd	BW	Li	Lo			Mu	Be	KC	Ba	An	Ka	Gn	Gd	Cu	PH		Da	LC	Ma		SH		Wo	La
Typhaceae																									
<i>Typha domingensis</i>								Be	KC				Gn						LC			SH	HB		
<i>Typha orientalis</i>																							HB		
Uvulariaceae (Liliaceae)																									
<i>Schelhammera undulata</i>	Bd	BW		Lo	Mm				KC	Ba	An	Ka	Gn						LC			SH			
Xanthorrhoeaceae																									
<i>Xanthorrhoea arborea</i>	Bd	BW	Li	Sp	Lo	Mm	Mu	Be	KC	Ba	An	Ka	Gn	Gd		PH			LC			SH			
<i>Xanthorrhoea macronema</i>	Bd	BW		Sp		Mm			KC																
<i>Xanthorrhoea media</i>	Bd					Mm	Mu	Be	KC			Ka	Gn	Gd		PH			LC	Ma	Wa	SH		Wo	
<i>Xanthorrhoea minor</i>													Gn		Cu						Wa	SH			
<i>Xanthorrhoea resinifera</i> (<i>X. resinosa</i>)		BW		Sp		Mm	Mu	Be	KC				Gn	Gd				Da		Ma		SH			La
Xyridaceae																									
<i>Xyris complanata</i>								Be																	
<i>Xyris gracilis</i> subsp. <i>gracilis</i>	Bd	BW		Sp	Lo			Be	KC				Gn	Gd								SH			La
<i>Xyris gracilis</i> subsp. <i>laxa</i>		BW		Sp					KC																
<i>Xyris juncea</i>								Be	KC																
<i>Xyris operculata</i>	Bd	BW		Sp		Mm	Mu		KC				Gn									SH			La

Discussion

Regional affinities

Sydney's Hawkesbury Sandstone vegetation is part of the world-renowned Sydney Basin sandstone flora. The flora represents probably the richest assemblage of xeromorphic species in eastern Australia and is a remnant of the xeromorphic assemblage that has spanned the continent in the past, especially in the south (Beadle 1981). Sandstone vegetation is part of Beadle's Eucalypt Woodlands and Forests on Soils of Low Fertility Chiefly on the Eastern Coastal Lowlands (Beadle 1981), and Coastal sandstone in particular of his *Eucalyptus gummifera*–*Eucalyptus racemosa*–*Eucalyptus sieberi* Alliance.

The forests on shale are part of Beadle's Tall Eucalyptus Forests of the Eastern Coastal Lowlands mostly on Soils of Higher Fertility, and generally attributable to his *Eucalyptus pilularis* Alliance, *Eucalyptus maculata* Alliance or *Eucalyptus saligna* Alliance.

The coastal sand dune remnants are probably the southern extremity of the north coastal Wallum country (and part of Beadle's *Banksia aemula* [= *B. serratifolia*] and related Alliances). Saltmarsh vegetation includes mixtures of tropical and temperate influences, while mangroves, with only two species in the Sydney area, reflect a decreasing species richness in southern Australia.

Historical changes

The vegetation map provides a picture of the distribution of vegetation at one point in the present time, and while it is obvious that these patterns have changed since 1788 as a result of clearing, it is not always appreciated that there has been considerable change in vegetation distribution as climate and geological patterns have changed over thousands and millions of years. Although our knowledge of these past conditions is still sketchy, we are beginning to see some of the patterns, at least of the more recent past. For example, during the last 1.8 million years (in the Quaternary Period) colder and warmer periods alternated (Chapman et al. 1982, Benson & Howell 1990a). Dune sands were blown inland from the coast where today's southern and eastern suburbs lie. About 20 000 years ago, during the coldest part of the last of the Pleistocene ice ages, the sea fell to its lowest level, 120–140 m below the present. As it rose again to reach its present level about 6 000 years ago, it drowned the coastal river valleys to form Broken Bay and Pittwater, Sydney Harbour, Botany Bay and Port Hacking, and swept up the offshore sands on to the modern beaches, sometimes damming smaller streams to form lagoons such as at Narrabeen and Dee Why.

Pollen and charcoal analyses of sediments from South Salvation Creek Swamp in Ku-ring-gai Chase National Park (Kodala & Dodson 1989) indicate that pollen influx has been dominated by local swamp species and dry sclerophyll heath and woodland taxa for the last 6 000 radiocarbon years, but that fluctuations in their abundances and/or distributions have occurred. These are likely to be the result of a combination of factors, including watertable fluctuations, seasonal drought, fire

activity, interspecific competition, the natural changing patterns in species distributions and the impact of Aboriginal and European people. None of these recent vegetation changes could be ascribed directly to climatic shifts, though changes in swamp and terrestrial pollen taxa around 2000 B.P. may indicate a drier climate than the present.

The impact of the Aborigines

Aboriginal people have been associated with the Sydney area for many thousands of years. Favoured living places were along the shorelines and along the Hawkesbury-Nepean River flats (Kohen & Lampert 1987, Kohen & Downing 1992).

On the coast plentiful supplies of seafood were supplemented with fruits, nectar, roots and tubers from plants growing on the extensive sand dunes and swamps that stretched from Bondi to Botany Bay and in the shrubby woodland and open-forest of the rocky harbour foreshores and nearby sandstone country (Benson & Howell 1990a). Sandstone gullies with rainforest-type vegetation would have provided further food sources, together with rocky overhangs and caves suitable for shelters and work sites.

It is hard to tell whether Aboriginal people altered the natural distribution or abundance of any food species either deliberately by planting, or accidentally by leaving remains associated with camp sites, nor is there evidence for changes in species abundance due to over-exploitation. However, Aboriginal people affected the vegetation by their use of fire and there has been a considerable amount written on this (e.g. see Nicholson, 1981). Many accounts contain very generalised statements often making reference to Aboriginal fire usage in Central and Northern Australia. Such usage does not necessarily apply to Southern Australia and, as far as the Sydney area is concerned, only limited observations were recorded before the effects of European settlement quickly overwhelmed Aboriginal society.

Possibly the most important point is that the Aborigines are likely to have managed different types of country differently. For example, they are likely to have burnt the open grassy understorey of the typical Cumberland Plain vegetation of western Sydney fairly frequently, probably with creeping or low-intensity fires. Such fires would have stimulated green shoots and provided favourable conditions for grazing animals. They would also have stimulated flowering in tuberous herbs such as orchids, which would have made them conspicuous. It is likely that such fires burnt at low intensity, as the trees were well-spaced and there would be limited fuel build-up. Such fires would be easily stopped by geographical features such as creeks, or indeed tracks, resulting in a patchy mosaic of burnt areas.

On the sandstone areas, however, it is likely that there were fewer fires, but that they burnt at higher intensities. Because of the shrubby nature of the vegetation, there would probably have been less game, and Aboriginal movement would have been more restricted by the topography than on the open Cumberland Plain. It seems less likely that deliberate burning would have been carried out on a broadscale basis, and more likely to have been localised around campsites and travelling routes to keep them clear, as well as around small-scale hunting sites such as individual



Figure 30. Signs of Aboriginal occupation, such as these axe-grinding grooves beside a rock pool, may still be found in bushland reserves within a few kilometres of the city centre.

trees. It is likely that hot summer fires would have been a feature of the sandstone areas, possibly on a 10–20 year cycle. On the sandstone the understorey is shrubby and very varied. Most species regenerate after fire, but some are killed, and it takes 3–10 years for recovery to reproductive maturity of most of these shrub species (Bradstock & Myerscough 1981, Benson 1985, Bradstock 1990). Clark & McLoughlin (1986) report similar findings for the Lane Cove valley catchment, where burning was likely to have been more frequent on the shale ridges (at 1–5 year intervals) than on the sandstone slopes (7–15 year intervals).

The impact of the Europeans

An idea of how the country around Sydney appeared to the British colonists comes through in this 1827 description by writer Peter Cunningham, not to be confused with Allan Cunningham, the botanist. 'In Cumberland, the land immediately bordering upon the coast is of a light, barren, sandy nature, thinly be sprinkled with stunted bushes; while from ten to fifteen miles interiorly, it consists of a poor clayey or ironstone soil, thickly covered with our usual evergreen forest timber and underwood. Beyond this commences a fine timbered country, perfectly clear of bush, through which you might, generally speaking, drive a gig in all directions, without any impediment in the shape of rocks, scrubs or close forest. This description of country commences immediately beyond Parramatta on one hand, and Liverpool on the other; stretching in length south easterly obliquely towards the sea, about forty miles and varying in breadth near twenty. The soil upon the immediate banks of the rivers is generally rich flooded alluvial, but in the forests partakes commonly of a poor clayey or ironstone nature, yet bearing tolerably crops, even without manure, at the outset'.

This extract clearly shows how the geology and its accompanying vegetation directed the pattern of settlement. The barren Hawkesbury Sandstone and aeolian sand deposits of the country around Port Jackson, particularly the present Eastern Suburbs, i.e. 'immediately bordering upon the coast', with its stunted sclerophyllous vegetation, was agriculturally useless to the settlers. 'Ten to fifteen miles interiorly' would have included country from Homebush and Bankstown, west to Parramatta and Liverpool which had Wianamatta Shale with ironstones and clay soil. This would have supported eucalypt open forests with shrubby understoreys including much Paperbark, *Melaleuca decora*. Beyond Liverpool and Parramatta is the 'fine timbered' Cumberland Plain, gently undulating to flat country with deep clay soils supporting an open grassy woodland community. The rich alluvial soils on the river banks are mentioned, but no reference is made of the tall open forest that this supported. Much of this forest, particularly on the Hawkesbury, had been cleared for agriculture by 1830.

From very early days some plant communities were sought and cleared, while others were avoided. With the exception of small areas at Sydney (at Farm Cove) and at Rose Hill, the first intensively cultivated lands were the rich alluvial flats of the Hawkesbury-Nepean River at Windsor and Richmond. At the same time the grassy woodlands of the Cumberland Plain were beginning to be grazed. Sheep were the main grazing animals and were at first tended by shepherds until fencing made them redundant. The granting of land was followed by sporadic clearing of trees to encourage the growth of grass, then more extensive ring-barking or sapping. Extensive areas were often cleared of every tree. In 1844, for example, Mrs Meredith described how 'Homebush', halfway between Sydney and Parramatta, had been completely cleared of every tree for 1000 acres (Benson & Howell 1990a). Along the North Shore, and the northern suburbs from Epping to Hornsby, the tall open-forests of Blackbutt and Blue Gum were logged and then, because of the good soil and high rainfall, cleared to make way for dairy farms and orchards. In contrast, the shrubby forests and woodlands on the Hawkesbury Sandstone, because of their poor agricultural soils, remained largely undisturbed and were used only as sources of firewood, fence posts or small timber.

From the 1850s railway lines were built, radiating from Sydney. For engineering reasons these followed the most level routes. This was generally along the Wianamatta Shale country to the west and south, and later along the North Shore ridge to Hornsby. Suburbs followed the railways, and by the turn of the century extensive housing had spread from Sydney to Burwood in the west and to Hurstville in the south. Electric tramways made other areas accessible for housing, particularly in the harbourside Eastern suburbs, where the rows of stepped terrace houses which were built emphasize the steep nature of the original sandstone topography. Ferry services opened other harbourside sandstone sites to suburban development; for example Balmain, Mosman and the lower North Shore.

The North Shore railway, the car and the Sydney Harbour Bridge made the North Shore area increasingly accessible. Its remnant tall Blackbutts and Blue Gum trees, its milder climate, compared with the western suburbs of Sydney, and the adjacent

natural bushland gullies along the rugged Lane Cove River valley and upper Middle Harbour have made this one of the most sought after of Sydney's suburban areas. Particularly since the Second World War, bushland on Hawkesbury Sandstone has been increasingly cleared for suburban housing though there has been an increasing interest in retaining native vegetation as urban bushland. By contrast, and mainly because of the gentler topography of the country and lack of obviously colourful shrubs, bushland on the shale areas of western Sydney has been cleared for suburban development with little recognition given to any native plants that manage to survive.

Rare or endangered species

The occurrence of species in the major conservation areas (Table 4) gives a measure of the floristic richness of the map sheet area. For example, 566 native species and 82 exotic species have been recorded from Ku-ring-gai Chase National Park (Thomas & Benson 1985a). Seventy-eight significant plant species are listed for the Sydney map sheet area (Table 5), forty-one of which are listed as nationally rare or endangered species (Briggs & Leigh 1988) or of regional significance. Species listed are either rare, threatened or of botanical significance in terms of geographic distribution. The list contains species of varying rarity and conservation status: for example, *Allocasuarina portuensis* is a recently discovered species restricted to Sydney Harbour National Park; a number of the *Darwinia* species have locally restricted distributions; and *Tetratheca juncea* originally occurred in the Carlton to Undercliff area but is now almost certainly extinct there (Payne 1993). *Lampranthus tegens*, possibly originating in South Africa but not able to be equated with any known African species, therefore needs protection of populations here (Benson & McDougall 1993). Other species are restricted to fragments of almost totally cleared vegetation types, e.g. Eastern Suburbs *Banksia* scrub. Vegetation surveys for major conservation reserves generally include specific lists for those areas (e.g. Thomas & Benson 1985a, b).

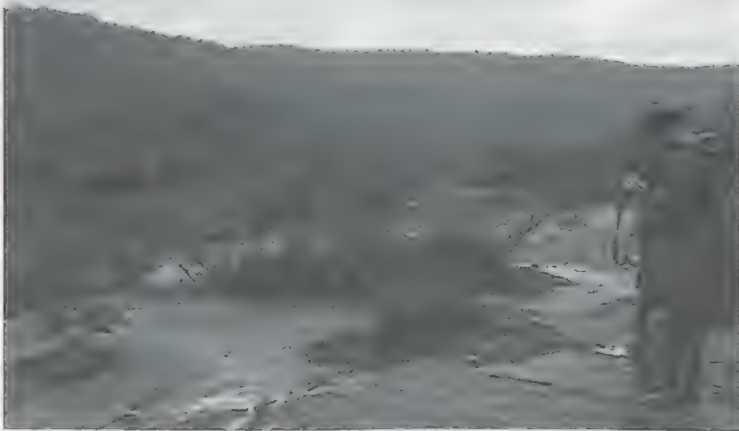


Figure 31. The rare plant *Kunzea rupestris* is confined to a few rock platforms in north-western Sydney.

Table 5. Species of particular conservation significance within the Sydney 1:100 000 map sheet area

Species listed here are either rare or threatened, or of botanical significance in terms of geographic distribution or localised populations disjunct from other occurrences. Localities refer to Sydney map sheet occurrences. Conservation codings are from Briggs & Leigh (1988) with current ROTAP updates. Nth = northern, Sth = southern, NP = National Park, NR = Nature Reserve

Family/species	Habitat/locality	Significance
Aizoaceae		
<i>Lampranthus tegens</i>	Saltmarsh, Homebush Bay	Only known wild populations of this species (Benson & McDougall 1993)
Apiaceae		
<i>Lilaeopsis polyantha</i>	Dee Why Lagoon	Local population
<i>Platysace clelandii</i>	Muogamarra NR, Marramarra Creek	2RCa
<i>Platysace stephensonii</i>	Ridgetop, Deep Creek	3RC-
Araliaceae		
<i>Astrotricha crassifolia</i>	Woy Woy, Warrah	Local endemic
Casuarinaceae		
<i>Allocauarina diminuta</i>	Kingsford	Local disjunct population
<i>Allocauarina nana</i>	Ridgetop, Deep Creek	Local disjunct population
<i>Allocauarina portuensis</i>	Nielsen Park	2ECit, local endemic
Chenopodiaceae		
<i>Halosarcia pergranulata</i> subsp. <i>pergranulata</i>	Saltmarsh, Homebush Bay	Local disjunct population
Convolvulaceae		
<i>Wilsonia backhousei</i>	Saltmarsh, Homebush Bay	Local population, rare
Dilleniaceae		
<i>Hibbertia nitida</i>	Thornleigh, Garigal NP, Oatley	2RC-
<i>Hibbertia virgata</i>	Sand dunes, Eastern Suburbs	Nth-limit
Epacridaceae		
<i>Epacris purpurascens</i> var. <i>purpurascens</i>	Gosford-Sydney	2KC-, local endemic
Euphorbiaceae		
<i>Bertya brownii</i>	Katandra, Mona Vale	2RC-, Sth-limit
<i>Pseudanthus pimeleoides</i>	Open-forest, ridges, Terrey Hills	Local populations, rare
Fabaceae		
<i>Acacia bynoeana</i>	Pennant Hills, Northbridge, Mosman, Cooks River	3VC-, probably locally extinct
<i>Acacia quadrilateralis</i>	Malabar	Sth-limit, locally extinct
<i>Acacia pubescens</i>	Bankstown, Belmore, Flemington, Rookwood	2VCa

<i>Daviesia umbellulata</i>	Pittwater	Rare local population
<i>Mirbelia speciosa</i>	Marramarra, Ku-ring-gai	Uncommon
<i>Pultenaea dentata</i>	Coastal heath, La Perouse Nth-limit	Local disjunct population
<i>Pultenaea hispidula</i>	Belrose, Allambie, shale/lateritic soils	Local populations, uncommon
<i>Pultenaea pedunculata</i>	Yennora	Local population, probably extinct in NSW
<i>Pultenaea viscosa</i>	Open-forest, Pennant Hills Park	Rare
Goodeniaceae		
<i>Dampiera scottiana</i>	Marramarra	Local disjunct population Nth-limit
Haloragaceae		
<i>Gonocarpus salsoloides</i>	North Head, Rose Bay, La Perouse	3RCa, local populations
<i>Haloragodendron lucasii</i>	Barra brui	2ECi, local endemic, rare
Lamiaceae		
<i>Prostanthera denticulata</i>	Lower hillslopes, Ku-ring-gai Chase NP Garigal NP	Local endemic, uncommon
Loganiaceae		
<i>Logania pusilla</i>	Muogamarra, Katandra	Local populations, rare
Myrtaceae		
<i>Angophora crassifolia</i>	Ridgetop, Deep Creek Frenchs Forest	2RCa, local endemic
<i>Darwinia biflora</i>	Hawkesbury River– Port Jackson	2VCa, local endemic
<i>Darwinia diminuta</i>	Terrey Hills–Manly– Sutherland–Bulli	3RCi, local endemic
<i>Darwinia leptantha</i>	Coastal heath, North Head–Cronulla	Local disjunct population
<i>Darwinia peduncularis</i>	Hornsby–Hawkesbury River	3RCi, local disjunct populations
<i>Darwinia procera</i>	Gosford–Manly	2RCa, local endemic
<i>Eucalyptus acmenoides</i>	Wianamatta Shale, Galston, Ryde	Rare, Sth-limit
<i>Eucalyptus camfieldii</i>	North Head, Killara, Hornsby, Ku-ring-gai Chase NP, Dural	2VCi, local populations
<i>Eucalyptus capitellata</i>	Residual clay cappings Brisbane Water NP St Ives, Allambie Heights	Local populations, now uncommon
<i>Eucalyptus luehmanniana</i>	Heath on sandstone, northern Sydney	2RCa, local populations
<i>Eucalyptus robusta</i>	Swamp-forest, Gosford, Pittwater	Local populations, now rare

<i>Eucalyptus scias</i>	Pittwater–Warringah	Local populations, rare
<i>Kunzea rupestris</i>	Canoelands, Ku-ring-gai Chase NP	2VCi, local endemic
<i>Leptospermum deanei</i>	Marramarra Creek, Pennant Hills Park, Middle Harbour Creek	2V, local endemic
<i>Melaleuca deanei</i>	Dry scrub, Hornsby, Pennant Hills Park, Lane Cove, Garigal NP, Earlwood	3RC-, local populations
<i>Micromyrtus blakelyi</i>	Rocky ridges, Muogamarra NR, Marramarra NP	2VCi-, local endemic
<i>Syzygium paniculatum</i>	Balgowlah, Wolli Creek	3VCi, local populations
Proteaceae		
<i>Banksia aemula</i>	Pleistocene sand, Bouddi, North Head, La Perouse	Local disjunct populations, southern limit
<i>Grevillea caleyi</i>	Terrey Hills to Belrose	2ECi, local endemic
<i>Grevillea linearifolia</i> (narrow-leaved form)	Marramarra, Arcadia	Local form
<i>Hakea bakeriana</i>	Marramarra	Rare, Sth-limit
<i>Persoonia hirsuta</i>	Deep Creek	3KCi
<i>Persoonia mollis</i> subsp. <i>maxima</i>	Hornsby	2E, local endemic subspecies
<i>Symphionema paludosum</i>	Brisbane Water NP, Belrose	Local populations, uncommon
Rutaceae		
<i>Asterolasia elegans</i>	Moist forest, north of Maroota	2ECi, restricted local endemic
<i>Boronia floribunda</i>	Open-forest, Pennant Hills Turramurra, Garigal NP	Uncommon
<i>Boronia fraseri</i>	Ku-ring-gai Chase NP Marramarra NP	2RCa, local endemic
<i>Boronia serrulata</i>	Brisbane Water, Arcadia, Ku-ring-gai Chase NP	2RC-, rare, once common in northern Sydney
<i>Zieria involucreta</i>	Marramarra Creek	2RCa
Sterculiaceae		
<i>Lasiopetalum joyceae</i>	Ku-ring-gai Chase NP, Arcadia	2RC-, local endemic
<i>Lasiopetalum macrophyllum</i>	Marramarra, Ku-ring-gai	Uncommon
<i>Rulingia hermanniifolia</i>	Coastal heath, Bouddi–Cronulla	3RCa, Nth-limit, rare
Tremandraceae		
<i>Tetratheca glandulosa</i>	Wisemans Ferry–Port Jackson	2VC-, local populations, Sth-limit
<i>Tetratheca juncea</i>	Sandstone, Carlton–Tempe, Rookwood	3VCi, Sth-limit, locally extinct
<i>Tetratheca neglecta</i>	Sandstone, Arncliffe–Como	3RC-, rare, Nth-limit

Monocotyledons**Anthericaceae**

<i>Alania endlicheri</i>	Moist cliff-faces, Arcadia	Local population
--------------------------	----------------------------	------------------

Araceae

<i>Typhonium eliosurum</i>	Patonga Creek	3RC-, rare
----------------------------	---------------	------------

Cyperaceae

<i>Baumea muelleri</i>	Damp heath, Katandra, Oxford Falls	Sth-limit
<i>Gahnia filum</i>	Saltmarsh, Georges River	Nth-limit

Lomandraceae

<i>Lomandra brevis</i>	Ku-ring-gai Chase NP, Deep Creek, Kogarah	2RC-
<i>Lomandra fluviatilis</i>	Marramarra Creek, Deep Creek	3RCa

Orchidaceae

<i>Arthrochilus prolixus</i>	Avalon	Rare local population, southern limit
<i>Caladenia tessellata</i>	Berowra, Castlecrag, Tempe, Penshurst	3V, probably locally extinct
<i>Corybas undulatus</i>	St Ives, Frenchs Forest	3KC-, probably locally extinct
<i>Cryptostylis hunteriana</i>	Ku-ring-gai Chase NP	3VC-
<i>Genoplesium baueri</i>	Ku-ring-gai Chase NP, Deep Creek	3RC-
<i>Sarcochilus australis</i>	Marramarra	Uncommon

Poaceae

<i>Ancistrachne maidenii</i>	Berowra Creek	2KC-, local endemic
<i>Deyeuxia appressa</i>	Saltpan Creek, Killara	2E, local endemic

Conservation of vegetation

Despite the impact of the city of Sydney and its suburban sprawl, a surprising amount of natural vegetation has managed to survive. This includes large parklands on the edge of the suburban areas and many small patches within them. Survival has mainly been fortuitous, rather than planned. Because of the extent of the Hawkesbury Sandstone with its very limited agricultural capacity, many areas have remained uncleared, much as Crown land during the agricultural expansion of the nineteenth century.

The obvious attractiveness of the Hawkesbury Sandstone landscape scenery and flora and the relative uselessness of the land for farming led to pressure from the early and farsighted 'preservationists', in particular Eccleston du Faur, for the establishment of Ku-ring-gai Chase in 1892, Sydney's second major conservation area (following National Park (later Royal N.P) dedicated in 1879 for similar reasons). Lane Cove River National Park followed. Muogamarra Nature Reserve began as a private

'nature reserve' and was enlarged with Crown land. Marramarra National Park and Davidson State Recreation Area (now part of Garigal N.P.) were formed out of the considerable reserves of Crown land still available up to the 1980s. Similarly, the Commonwealth Government's holding of land on Sydney Harbour and Botany Bay for defence purposes inadvertently preserved much land that could have been built over but which was to become the nucleus for Sydney Harbour National Park. The rugged nature of the Hawkesbury sandstone landscape also resulted in small parks and reserves often being left in housing subdivisions in inaccessible sites.

Elsewhere the native vegetation disappeared. On the Wianamatta Shale soils woodland was cleared for grazing and agriculture, and then for suburban housing. Similar suburban development replaced the vegetation on the Eastern Suburbs sand dunes. Even with the far-sighted setting aside of Centennial Park, only a trifling patch of the original *Banksia* scrub survives, in the Bird Sanctuary. More extensive remnants survive at Long Bay and La Perouse, again largely because of Commonwealth Government control for military purposes. It is hoped these bushland areas will eventually be formally conserved. Reclamation programs to turn the mangrove and estuarine vegetation of the Parramatta and Georges Rivers into playing fields have been promoted for most of this century and have only just been stopped in time, leaving some remnants such as at Homebush Bay. Changes such as the cessation of landfill of mangroves have come about because of increased public awareness of the value of natural vegetation and the need to maintain biological diversity. This concern is now also directed towards the management and maintenance of reserved areas. There are two particularly pressing problems — exotic weed invasion and fire.

The invasion of urban bushland by exotic weed species was specifically highlighted by Adamson and Buchanan (1974), though the spread of weeds along watercourses into undisturbed areas is mentioned by Pidgeon (1938). *Ligustrum sinense* and *Ligustrum lucidum* (Privet species), *Lantana camara*, *Tradescantia albiflora* and a host of other weed species of garden escape origin, are able to invade normally resistant natural bushland where there has been some form of disturbance, particularly involving the addition of soil nutrients (Clements 1983). Characteristically these weeds form extensive thickets along creeks and drainage lines. The best method of restricting weed proliferation is to stop nutrients entering the soil from stormwater run-off and from creek floodwaters, and ways of reducing this have been suggested by Bliss et al. (1983). A method of hand-weeding was originated by Joan and Eileen Bradley in Mosman bushland (Bradley & Bradley 1966–74, Bradley 1971) and has been successfully developed as part of a bushland management strategy by the National Trust and other groups (National Trust 1991 — this also includes a list of its bushland surveys, Buchanan 1989, Bradley 1988).

The fragmentation of bushland in suburban areas and the potential fire hazard has led to the increased use of regular controlled burning for fuel reduction in some areas and decreased use of fire in others (Clark & McLoughlin 1986). Most of Sydney's native vegetation is adapted to fire, but at different frequencies for the different types and communities, because of aspect and topography. Although some species may regenerate well after fire, other species may be destroyed by frequent fire

which does not allow adequate time intervals for the build-up of seed banks (Benson 1985, Bradstock 1990). This means that the length of time between fires needed for species survival varies from community to community. Fire intensity is also an important factor; low intensity burns may not stimulate adequate native seedling regeneration while allowing weed growth (Bradley 1971). Different fire management approaches are therefore needed for different communities.

In the absence of fire, there is a tendency for species of wetter sites, such as *Pittosporum undulatum*, to predominate at the expense of those requiring fire for germination, such as members of the Fabaceae (Auld & O'Connell 1991). To achieve a balance between these factors, a long-term management program will need information based on observations on the behaviour of a wide range of species, together with a range of management options including the use of fire and selective land clearing.

The future

Sydney's bushland setting provides a major contribution to the individual character of the city. But bushland is still threatened by direct destruction for urban and recreational development, and indirectly by nutrient run-off, weed invasion, and shortsighted management. Bushland is particularly vulnerable to the 'tyranny of small decisions'. In the face of this, much of the responsibility for ensuring careful management of urban bushland has fallen to local residents and organisations keen to maintain the local identity of bushland areas. Public awareness of the need for protection and professional management of bushland is increasing, and recognition of its value needs to be supported by government policies and planning provisions at federal, state and local levels.

Such management involves the employment of professionally trained staff and the development of appropriate bushland and catchment management techniques. Management will often be constrained by lack of knowledge on the responses of plant species and vegetation. Additional supporting research is needed, as researchers are currently faced with a wide array of problems needing investigation. In the meantime, decisions will need to be made in terms of the reversibility of actions and keeping future options open. Successful conservation aims to maintain current levels of biological diversity, and this must be seen as a guiding principle.



Figures 32 & 33. Bushland slopes and gullies near urban areas provide a unique opportunity for Sydneysiders to grow up experiencing the natural world within the context of a city.

Acknowledgements

We wish to thank Helen Bryant for assistance in the collection of data, Bob Coveny for his generous assistance with plant identifications, Nining McCann and Commonwealth Employment Program (CEP) funding for assistance with the map, Lyn McDougall for assistance with the diagrams and the final manuscript, and a number of typists who assisted at different times, including Celia McGregor, Josie Sahagun, Cindy Douglas, Belinda Crews and Melinda Coles. Thanks also go to Richard McRae, Jeff Thomas and Peter Clarke for unlimited access to their data, and Chris Pratten, Lawrie Johnson, Graham Quint, Paul Adam, David Keith, Phillip Kodela, Peter Myerscough and others who provided comments and observations.

References

- Adam, P. (1991) *Flora and vegetation of the eastern part of the RAN Armaments Depot Newington* (NSW Govt, Property Services Group: Sydney).
- Adam, P., Stricker, P. & Anderson, D.J. (1989) Species richness and soil phosphorus in plant communities in coastal New South Wales. *Australian Journal of Ecology* 14: 189–198.
- Adam, P., Stricker, P., Wiecek, B.M. & Anderson, D.J. (1989) The vegetation of sea cliffs and headlands in New South Wales, Australia. *Australian Journal of Ecology* 14: 515–547.
- Adamson, D & Buchanan, R. (1974) Exotic plants in urban bushland in the Sydney region. *Proceedings of the Weed Society of New South Wales* 6: 24–27.
- Allaway & Clarke (1987) Wolli Creek estuarine wetlands. *Coast & Wetlands Society Newsletter* Number 22 (November).
- Andrews, A. (1984) *The Devil's wilderness: George Caley's journey to Mount Banks 1804*. (Blubber Head Press: Hobart).
- Armstrong, J., Benson, D.H. & Coveny, R. (1976) The vegetation of La Perouse. Unpub. report (Royal Botanic Gardens: Sydney).
- Atkinson, James (1826) *An account of the state of agriculture and grazing in New South Wales*. Facsimile Edn (Sydney University Press: Sydney, 1975).
- Auld, T.D. (1986) Population dynamics of the shrub *Acacia suaveolens* (Sm.) Willd.: Fire and the transition to seedlings. *Australian Journal of Ecology* 11: 373–85.
- Auld, T.D. & Myerscough, P.J. (1986) Population dynamics of the shrub *Acacia suaveolens* (Sm.) Willd.: Seed production and predispersal seed predation *Australian Journal of Ecology* 11: 219–234.
- Auld, T.D. & O'Connell, M.A. (1991) Predicting patterns of post-fire germination in 35 eastern Australian Fabaceae. *Australian Journal of Ecology* 16: 53–70.
- Beadle, N.C.W. (1953) The edaphic factor in plant ecology with a special note on soil phosphates. *Ecology* 34: 426–428.
- Beadle, N.C.W. (1962) Soil phosphate and the delimitation of plant communities in eastern Australia. *Ecology* 43: 281–288.
- Beadle, N.C.W. (1966) Soil phosphate and its role in molding segments of the Australian flora and vegetation with special reference to xeromorphy and sclerophylly. *Ecology* 47: 991–1007.
- Beadle, N.C.W. (1981) *The vegetation of Australia* (Cambridge University Press: Cambridge).
- Beadle, N.C.W. & Costin, A.B., (1952) Ecological classification and nomenclature. *Proceedings of the Linnean Society of New South Wales* 77: 61–74.
- Beecroft Cheltenham Civic Trust (1976) *A plan of management for Pennant Hills Park and some surrounding bushland* (Beecroft Cheltenham Civic Trust: Beecroft).
- Benson, D.H. (1974) Reconnaissance vegetation survey of Duffys Forest–Terry Hills area. Unpub. report (copy held in Royal Botanic Gardens Library).
- Benson, D.H. (1975) Brief survey of native vegetation at Rawson Park, Mosman. Unpub report (copy held in Royal Botanic Gardens Library).
- Benson, D.H. (1978a) Brief survey of vegetation at Long Bay Rifle Range. Unpub. report (copy held in Royal Botanic Gardens Library).
- Benson, D.H. (1978b) Brief vegetation survey–Wolli Creek–Undercliffe to Bexley North. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Benson, D.H. (1979a) Native vegetation of Deep Creek, Narrabeen. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Benson, D.H. (1979b) Report on native vegetation–Edna May Hunt Reserve, Hillside Crescent, Epping. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Benson, D.H. (1980a) Explanatory notes for the Sydney 1:100 000 vegetation map sheet. Unpub. (Royal Botanic Gardens: Sydney).
- Benson, D.H. (1980b) Species recorded from Joe's Mountain, Elouera Bushland Reserve in area not burnt since 1957. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Benson, D.H. (1980c) Report on native vegetation, Vineyard Creek Catchment Reserve, Telopea, New South Wales. Unpub. report (copy held in Royal Botanic Gardens Library).
- Benson, D.H. (1981a) Vegetation of Lion Island, Broken Bay, New South Wales. *Cunninghamia* 1: 121–123.
- Benson, D.H. (1981b) Native vegetation of Warringah–Manly War Memorial Park. Unpub. report (copy held in Royal Botanic Gardens Library).

- Benson, D.H. (1983) Plant species originally native in Concord Municipality. Appendix 1 in S. Coupe, *Concord: a century history 1883-1983* (Concord Municipal Council: Concord).
- Benson, D.H. (1984) List of plants growing on Bar Island, Hawkesbury River. Unpub. report (Royal Botanic Gardens: Sydney).
- Benson, D.H. (1985) Maturation periods for fire-sensitive shrub species in Hawkesbury Sandstone vegetation. *Cunninghamia* 1(3): 339-349.
- Benson, D.H. (1986a) The vegetation of the Gosford and Lake Macquarie 1:100 000 vegetation map sheet. *Cunninghamia* 1(4): 467-489.
- Benson, D.H. (1986b) Native vegetation-Brush Farm Park, Eastwood. Unpub. report (Royal Botanic Gardens Sydney).
- Benson, D.H. (1992a) The natural vegetation of the Penrith 1:100 000 map sheet. *Cunninghamia* 2(4): 541-596.
- Benson, D.H. (1992b) Botanical significance of native vegetation, Third Avenue, Campsie. Unpub. report (Royal Botanic Gardens: Sydney).
- Benson, D.H. & Howell, J. (1990a) *Taken for granted: the bushland of Sydney and its suburbs*. (Kangaroo Press: Kenthurst).
- Benson, D.H. & Howell, J. (1990b) Sydney's vegetation 1788-1988: utilization, degradation and rehabilitation. *Proceedings of the Ecological Society of Australia* 16: 115-127.
- Benson, D.H., Howell, J. & McDougall, L. (1989) Vegetation of Big Bay Island, Marramara Creek, Hawkesbury River, NSW. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Benson, D.H. & Keith, D.A. (1984a) Floristic List for Dalrymple Hay Nature Reserve. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Benson, D.H. & Keith, D.A. (1984b) Native vegetation, Fagan Park, Galston. Unpub. (Royal Botanic Gardens Sydney).
- Benson, D.H. & Keith, D.A. (1984c) Floristic List for Macquarie Hospital Bushland, Twin and Cressy Road, East Ryde. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Benson, D.H. & Keith, D.A. (1985) Species list for the Leo Smith Reserve, Ramsgate. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Benson, D.H. & Keith, D.A. (1990) The natural vegetation of the Wallerawang 1:100 000 map sheet. *Cunninghamia* 2(2): 305-335.
- Benson, D.H. & McDougall, L. (1993) Ecology of Sydney plant species part 1: ferns, fern-allies, cycads, conifers and dicotyledon families Acanthaceae to Asclepiadaceae. *Cunninghamia* 3(2): 257-422.
- Benson, D.H. & Melrose, S.C. (1993) Floristic lists of New South Wales. *Cunninghamia* 3(1): 167-213.
- Benson, J.S. & Fallding, H.B. (1981) Vegetation survey of Brisbane Water National Park and environs. *Cunninghamia* 1: 79-113.
- Blaxell, D.F. & Pickard, J. (1969) Floristic list-Lane Cove River. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Bliss, P.J., Riley, S.J. & Adamson, D. (1983) Towards rational guidelines for urban stormwater disposal into flora preservation areas. *Shire and Municipal Record* 191: 181-185.
- Bradley, E. & Bradley, J. (1966-1974) Local native plant species, Rawson Park, Mosman, New South Wales. Results of periodic plant surveys, 1966-1974. Unpub. report (copy held in the Royal Botanic Gardens, Library).
- Bradley, J. (1971) *Bush regeneration* (The Mosman Parklands and Ashton Park Association: Mosman).
- Bradley, J. (1988) *Bringing back the bush: the Bradley method of bush regeneration* (Lansdowne Press: Sydney).
- Bradstock, R.A. (1990) Demography of woody plants in relation to fire: *Banksia serrata* L.f. and *Isopogon anemonifolius* (Salisb.) Knight. *Australian Journal of Ecology* 15: 117-132.
- Bradstock, R.A. & Myerscough, P.J. (1981) Fire effects on seed release and the emergence and establishment of seedlings in *Banksia ericifolia* L.f. *Australian Journal of Botany* 29: 521-531.
- Briggs, J. & Leigh, J. (1988) *Rare or threatened Australian plants*. Revised edn. Special Publication No.14. (Australian National Parks & Wildlife Service: Canberra).
- Broadbent, J.A. & Buchanan, R. (1984) Ecological studies for extension of Rutledge Street across Brush Farm Park from Brush Road to Marsden Road, Eastwood. (Unpub. Report).

- Brough, P., McLuckie, J. & Petrie, A.H.K. (1924) An ecological study of the flora of Mount Wilson I. The vegetation of the basalt. *Proceedings of the Linnean Society of New South Wales* 49: 475-498.
- Brown, K.R., Krassoi, F.R., Angus, C. & Underwood, P. (1988) The mangroves of Wolli Creek, Sydney. *Wetlands (Australia)* 8: 27-29.
- Bryant, H.J. & Benson, D.H. (1981) Recent floristic lists of New South Wales. *Cunninghamia* 1(1): 59-77.
- Buchanan, R. (1978) Blackwood (National Trust of Australia (NSW) Unpub.).
- Buchanan, R. (1979a) *Mowbray Park; description and management*. (Mowbray Park Preservation Society: Lane Cove).
- Buchanan, R. (1979b) Burley Griffin Lodge Avalon. Unpub. (National Trust of Australia: NSW).
- Buchanan, R. (1980) The Lambert Peninsula, Ku-ring-gai Chase National Park. Physiography and the distribution of podzols, shrub lands and swamps, with details of the swamp vegetation and sediments. *Proceedings of the Linnean Society of New South Wales* 104: 73-94.
- Buchanan, R. (1987) The Ludovic Blackwood Memorial Sanctuary — description and management: ten years of bush regeneration assessment of permanent transects (National Trust of Australia (NSW) Unpub.).
- Buchanan, R. (1989) *Bush regeneration: recovering Australian landscapes*. (TAFE Student Learning Publications: Sydney).
- Buchanan, R. & Humphreys, G.S. (1980) The vegetation on two podzols on the Hornsby Plateau, Sydney. *Proceedings of the Linnean Society of New South Wales* 104: 49-71.
- Bureau of Meteorology (1979) *Climatic survey—Sydney, region 5, New South Wales*. (Department of Science & the Environment: Canberra).
- Burges, A. & Drover, D. P. (1952) The rate of podzol development in sands of the Woy Woy district, N.S.W. *Australian Journal of Botany* 1: 83-95.
- Burrell, J. (1981) Invasion of coastal heath by *Leptospermum laevigatum*. *Australian Journal of Botany* 29: 747-764.
- Centre of Environmental Studies (1978) *A Bicentennial Park for Sydney: Homebush Bay*. Report prepared for Concord Council by Macquarie University.
- Chapman, D.M., Geary, M., Roy, P.S. & Thom, B.G. (1982) *Coastal evolution and coastal erosion in New South Wales*. (Coastal Council of NSW: Sydney).
- Chapman, G.A. & Murphy, C.L. (1989) *Soil landscapes of the Sydney 1:100 000 sheet*. (Soil Conservation Service Of N.S.W.: Sydney).
- Clark, S.S. & McLoughlin, L.C. (1986) Historical and biological evidence for fire regimes in the Sydney region prior to the arrival of Europeans: implications for future bushland management. *Australian Geographer* 17: 101-112.
- Clarke, L.D. & Hannon, N.J. (1967) The mangrove swamps and salt marsh communities of the Sydney district. I. Vegetation, soils and climate. *Journal of Ecology* 55: 753-771.
- Clarke, L.D. & Hannon, N.J. (1969) The mangrove swamps and salt marsh communities of the Sydney district. II. The holocoenotic complex with particular reference to physiography. *Journal of Ecology* 57: 213-234.
- Clarke, L.D. & Hannon N.J. (1970) The mangrove swamps and salt marsh communities of the Sydney district. III. Plant growth in relation to salinity and waterlogging. *Journal of Ecology* 58: 351-369.
- Clarke, L.D. & Hannon, N.J. (1971) The mangrove swamps and salt marsh communities of the Sydney district. IV. The significance of species interaction. *Journal of Ecology* 59: 535-553.
- Clarke, P.J. & Benson, D.H. (1987) Vegetation survey of Lane Cove River State Recreation Area. (Royal Botanic Gardens: Sydney).
- Clarke, P. & Benson, D. (1988) The natural vegetation of Homebush Bay — two hundred years of changes. *Wetlands (Australia)* 8(1): 3-15.
- Cleland, J.B. (1914) List of plants growing upon Milson Island, Hawkesbury River. *Bureau of Microbiology* 3rd report., 218-225.
- Clemens, J. & Franklin, M.H. (1980) A description of coastal heath at North Head, Sydney Harbour National Park: Impact of recreation and other disturbance since 1951. *Australian Journal of Botany* 28: 463-478.
- Clements A. (1983) Suburban development and the resultant changes in the vegetation of the bushland of the northern Sydney region. *Australian Journal of Ecology* 8: 307-319.

- Collins, David (1798) *An account of the English colony in New South Wales*. (Facsimile Edition, B. Fletcher (ed.) (Royal Australian Historical Society/ A.H. & A.W. Reed: Sydney 1975).
- Corbett, J.R. (1972) Soils of the Sydney area. In *The city as a life system?* Ed. H.A. Nix. *Proceedings of the Ecological Society of Australia* 7: 41–76.
- Costin, P. (1986) Loquat Valley bushland group — plant species list. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Coveny, R. Checklists of plant sightings and collections for various areas. Unpub. reports (copies held in the Royal Botanic Gardens Library):
- a. Brush Farm, Eastwood, Sydney, (1978),
 - b. Cheltenham, Sydney, (1965–78),
 - c. Cowan to Jerusalem Bay, Ku-ring-gai Chase, Sydney, (1965–70),
 - d. Cumberland State Forest, Baulkam Hills, Sydney, (1976),
 - e. Darvall Park, Denistone Sydney, (1978) Additions and corrections, (1979)
 - f. Deep Creek, Narrabeen, Sydney, (1965–75),
 - g. Dee Why Lagoon, Sydney, (1970–72),
 - h. Elouera Bushland Reserve, Sydney, (1970)
 - i. Frenchs Forest, Sydney, (1965–70),
 - j. Glebe Gully, Randwick, Sydney, (1977),
 - k. Hallstrom Nature Reserve, Muogamarra, North of Sydney, (1962–69),
 - l. Katandra Sanctuary, Mona Vale, Sydney, (1975–79, 1988),
 - m. Lake Parramatta Reserve, Sydney, (1960–65),
 - n. Mt Ku-ring-gai to Apple Tree Bay, Sydney, (1960–65),
 - o. Manly Reservoir, Sydney, (1965–70),
 - p. North Head, Sydney, (1967).
- Coveny, R.G. & McDougall, L. (1990) Plant species on Long Island Nature Reserve, Hawkesbury River. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Cunningham, P. (1827) *Two years in New South Wales* (London).
- Currey, J.E.B. (ed.) (1966) *Reflections on the Colony of New South Wales: George Caley*. (Lansdowne Press: Melbourne).
- Davis, C. (1936) Plant ecology of the Bulli district. I. Stratigraphy, physiography and climate; general distribution of plant communities and interpretation. *Proceedings of the Linnean Society of New South Wales* 61: 285–297.
- Davis, C. (1941a) Plant ecology of the Bulli district. II. Plant communities of the plateau and scarp. *Proceedings of the Linnean Society of New South Wales* 66: 1–19.
- Davis, C. (1941b) Plant ecology of the Bulli district. II. Plant communities of the coastal slopes and plain. *Proceedings of the Linnean Society of New South Wales* 66: 20–32.
- Forestry Commission of NSW (1984) *Management plan for Cumberland Management area*.
- Hamilton, A.A. (1918) Topographical, ecological and taxonomic notes on the ocean shoreline vegetation of the Port Jackson district. *Journal and Proceedings of the Royal Society of New South Wales* 51: 287–355.
- Hamilton, A.A. (1919) An ecological study of the saltmarsh vegetation in the Port Jackson district. *Proceedings of the Linnean Society of New South Wales* 44: 463–513.
- Hannon, N.J. (1956) The status of nitrogen in the Hawkesbury Sandstone soils and their plant communities in the Sydney district I. The significance and level of nitrogen. *Proceedings of the Linnean Society of New South Wales* 81: 199–243.
- Hannon, N.J. (1958) The status of nitrogen in the Hawkesbury Sandstone soils and their plant communities in the Sydney district II. The distribution and circulation of nitrogen. *Proceedings of the Linnean Society of New South Wales* 83: 65–85.
- Harden, G.J. (ed) (1990–3) *Flora of New South Wales Volumes 1–4* (NSW University Press: Kensington).
- Hawkins, R. (1994) *The convict timbergetters of Pennant Hills: a history and biographical register* (Hornsby Shire Historical Society: Sydney).
- Herbert, C. (ed.) (1983) *Geology of the Sydney 1:100 000 sheet 9130*. (N.S.W. Department of Mineral Resources: Sydney).
- Holland, D. (1980) Mount Trefle: a general and botanical study within Sydney Harbour National Park (Unpub. student report to Ryde School of Horticulture).
- Horton, S. (1986) A vegetation survey of North Head. Draft report (National Parks & Wildlife Service of New South Wales).
- Kachka, A.M. (1993) *Vegetation survey of Homebush Bay*. (NSW Govt, Property Services Group: Sydney).

- Kartsoff, M. (1969) *Nature and a city: the native vegetation of the Sydney area*. (Edwards & Shaw: Sydney).
- Keith, D.A. (1988) Floristic lists of New South Wales (III). *Cunninghamia* 2(1): 39–73.
- Keith, D.A. & Benson, D.H. (1988) The natural vegetation of the Katoomba 1:100 000 map sheet. *Cunninghamia* 2(1): 107–143.
- Keith, D.A. & Myerscough, P.J. (1993) Floristics and soil relations of upland swamp vegetation near Sydney. *Australian Journal of Ecology* 18: 325–344.
- Kodala, P.G. & Dodson, J.R. (1989) A late Holocene vegetation and fire record from Ku-ring-gai Chase National Park, New South Wales. *Proceedings of the Linnean Society of New South Wales* 110: 317–326.
- Kohen, J.L. & Lampert, R. (1987) Hunters and fishers in the Sydney region. In *Australians to 1788* (S.J. Mulvaney & P.J. White eds. Fairfax, Syme & Weldon Associates: Sydney).
- Kohen, J.L. & Downing, A.J. (1992) Aboriginal use of plants on the western Cumberland Plain. *Sydney Basin Naturalist* 1: 1–8.
- Kratochvil, M., Hannon, N.J. & Clarke, L.D. (1973) Mangrove swamp and salt marsh communities in southern Australia. *Proceedings of the Linnean Society of New South Wales* 97: 262–274.
- Lee, I. (1925) *Early explorers in Australia* (Methuen & Co: London).
- McDougall, L. (1989) Lion Island, additional species. Unpub. report (copy held in the Royal Botanic Gardens Library).
- McDougall, L. (1993) Plant list for Marramarra National Park. Unpub. (Royal Botanic Gardens Sydney).
- McDougall, L. (1994) List of plant species for Barrenjoey Headland. Unpub. (Royal Botanic Gardens Sydney).
- McDougall, L. & Conroy, R. (1988–90) Species list for Davidson Park State Recreation Area. Unpub. (National Parks & Wildlife Service: Ku-ring-gai).
- McKern, J.G. (1962) Deep Creek–Narrabeen proposed parks. List of some plants. *Australian Wild Life* 4: 4–7.
- McLoughlin, L. (1985) *The Middle Lane Cove River: A history and a future*. Monograph No.1 Centre for Environmental and Urban Studies (Macquarie University: Sydney).
- McLuckie, J. & Petrie, A.H.K. (1926) An ecological study of the flora of Mount Wilson III. The vegetation of the valleys. *Proceedings of the Linnean Society of New South Wales* 51: 94–113.
- McRae, R.H.D. (1990) Vegetation of Bouddi Peninsula, New South Wales. *Cunninghamia* 2(2): 263–293.
- Maiden, J.H. (1889) *The useful native plants of Australia*. (Facsimile edn. Compendium: Melbourne 1975).
- Maiden, J.H. (1902) List of plants growing without cultivation in the Outer Domain. *Annual Report for Botanic Gardens and Domain for year 1902*, 29.
- Meredith, Mrs Charles (1844) *Notes and Sketches of New South Wales*. (Facsimile edn. Penguin Books: Harmondsworth, 1973).
- Myerscough P.J. & Carolin R.C. (1986) The vegetation of the Eurunderie sand mass, headlands and previous islands in the Myall Lakes area, New South Wales. *Cunninghamia* 1(4): 399–466.
- National Trust (1991) *Urban bushland: a National Trust policy paper*. (National Trust of Australia (NSW: Sydney).
- NSW Department of Mines (1966) *Sydney 1:250 000 Geological Series Sheet*. Edition 3. (Department of Mines: Sydney).
- NSW Department of Mineral Resources (1983) *Sydney 1:100 000 Geological Series Sheet 9130 (Edition 1)* (Department of Mineral Resources: Sydney).
- NSW National Parks & Wildlife Service (1994) List of plant species in Marramarra National Park (from database).
- NSW National Parks & Wildlife Service (1994) Lists of plant species for Bradleys Head, Clifton Gardens, Dobroyd Head, Neilsen Park.
- Nicholson, P.H. (1981) Fire and the Australian Aborigine — an enigma. Chapter 3 in *Fire and the Australian biota*. (A.M. Gill, R.H. Groves & I.R. Noble eds. Australian Academy of Science: Canberra).
- Outhred, R., Lainson, R., Lamb, R & Outhred, D. (1985) A floristic survey of Ku-ring-gai Chase National Park. *Cunninghamia* 1: 313–338.
- Payne, R.J. (1993) Prediction of the habitat for *Tetratheca juncea* in the Munmorah area, near Wyong, New South Wales. *Cunninghamia* 3(1): 147–154.

- Petrie, A.H.K. (1925) An ecological study of the flora of Mount Wilson II. The *Eucalyptus* forests. *Proceedings of the Linnean Society of New South Wales* 50: 145–166.
- Phillip, Arthur (1789) *The voyage of Governor Phillip to Botany Bay*. Facsimile edition Hutchinson Group (Australia): Melbourne 1982.
- Phillips, M.E. (1947) Vegetation of the Wianamatta Shale and associated soil types. M.Sc. thesis (University of Sydney).
- Pickard, J. (1972) Annotated bibliography of floristic lists of New South Wales. *Contributions from the N.S.W. National Herbarium* 4: 291–317.
- Pickard, J. (1974) Report on saline swamp—Calna and Berowra Creeks. Unpub. report (copy held in Royal Botanic Gardens Library).
- Pidgeon, I.M. (1937) The ecology of the Central Coastal area of New South Wales. I. The environment and general features of the vegetation. *Proceedings of the Linnean Society of New South Wales* 62: 315–340.
- Pidgeon, I.M. (1938) The ecology of the Central Coastal area of New South Wales. II. Plant succession on the Hawkesbury Sandstone. *Proceedings of the Linnean Society of New South Wales* 63: 1–26.
- Pidgeon, I.M. (1940) The ecology of the Central Coastal area of New South Wales. III. Types of primary succession. *Proceedings of the Linnean Society of New South Wales* 65: 1–26.
- Pidgeon, I.M. (1941) The ecology of the Central Coastal area of New South Wales. IV. Forest types on soils from Hawkesbury Sandstone and Wianamatta Shale. *Proceedings of the Linnean Society of New South Wales* 66: 113–137.
- Pratten, C.H. (1993) A parable of a sower — Ashfield's first land grant. *Journal of the Ashfield & District Historical Society* 10: 14–32.
- Price, G.A. (1979) The vegetation of Duck River and Rookwood Cemetery, Auburn. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Raymond, J. (1832) The New South Wales calendar and general Post Office directory (Stephens & Stokes: Sydney).
- Robinson, L. (1986) *Trees of Wolli Creek*. (Wolli Creek Preservation Society: Earlwood).
- Robinson, L. (1987) *Flora of the Wolli Creek valley* (Wolli Creek Preservation Society: Earlwood).
- Rodd, A.N. & Benson, D.H. (1977) Garden Island Dockyard — botanical survey. Unpub. report (copy held in the Royal Botanic Gardens Library).
- Rose, A.B. (1982) A list of plant species in Ku-ring-gai Chase National Park based on *A census of trees and plants in Ku-ring-gai Chase* by O.D.Evans, 1959. With additional observations by D.F. Blaxell, T.S. Barratt & A.B. Rose, 1969, revised 1982 (NSW National Parks & Wildlife Service: Sydney).
- Sanders, J. (1983) Differences in vegetation on soils associated with basalt dykes in Ku-ring-gai Chase National Park. Unpub. Bachelor of Science (Honours) Thesis (School of Biological Sciences, University of Sydney).
- Sanders, J., Bedward, M., Leahy, B., Robinson, M. & Sheringham, P. (1988) *Preliminary report on the vegetation of Yengo National Park and Parr State Recreation Area*. (National Parks & Wildlife Service: Sydney).
- Sheringham, P.R. & Sanders, J. (1993) *Vegetation survey of Garigal National Park & surrounding Crown Lands*. (National Parks & Wildlife Service: Sydney).
- Siddiqi, M.Y., Carolin, R.C. & Anderson, D.J. (1972) Studies in the ecology of coastal heath in New South Wales. I. Vegetation structure. *Proceedings of the Linnean Society of New South Wales* 97: 211–224.
- Siddiqi, M.Y., Carolin, R.C. (1976a) Studies in the ecology of coastal heath in New South Wales. II. The effects of water supply and phosphorus uptake on the growth of *Banksia serratifolia*, *B. aspleniifolia* and *B. ericifolia*. *Proceedings of the Linnean Society of New South Wales* 101: 38–52.
- Siddiqi, M.Y., Carolin, R.C. & Myerscough, P.J. (1976b) Studies in the ecology of coastal heath in New South Wales. III. Regrowth of vegetation after fire. *Proceedings of the Linnean Society of New South Wales* 101: 53–63.
- Smith, P. & Smith, J. (1990) Vegetation and fauna of Berowra Valley Bushland Park (report prepared for Hornsby Shire Council).
- Smith, P. & Smith, J. (1993) *Angophora Reserve and Hudson Park: Plan of Management* (Pittwater Municipal Council).
- South Turrumurra Environment Protection (1980) A plan of management for South Turrumurra bushland (South Turrumurra Environment Protection: Turrumurra).

- Specht, R.L. (1970) Vegetation, in *The Australian Environment* (G.W. Leeper Ed., 4th Edition). (CSIRO-Melbourne University Press: Melbourne).
- Strom, B.(ed.) (1986) *Bouddi Peninsula study* (Association for Environmental Education NSW: Killcare Heights).
- Tench, Watkin (1979) *Sydney's first four years: being a reprint of A Narrative of the Expedition to Botany Bay and A Complete Account of the Settlement at Port Jackson* (Library of Australian History: Sydney).
- Thomas, J. & Benson, D.H. (1985a) Vegetation survey of Ku-ring-gai Chase National Park. Unpub. report (copy held in Royal Botanic Gardens Library).
- Thomas, J. & Benson, D.H. (1985b) Vegetation survey of Muogamarra Nature Reserve. Unpub. report, updated 1991 (copy held in Royal Botanic Gardens Library).
- Thorogood, C.A. (1985) Changes in the distribution of mangroves in the Port Jackson-Parramatta River estuary from 1930 to 1985. *Wetlands (Australia)* 5(2): 91-96.
- Upper Middle Harbour Conservation Committee (1974) *Bantry Bay: the case for conservation*. (Upper Middle Harbour Conservation Committee: Killarney Heights).
- Walker, P.H. (1960) *A soil survey of the County of Cumberland, Sydney region, New South Wales*. Bulletin No: 2, Soil Survey Unit, New South Wales Department of Agriculture.
- Webb, J. (1981) Vegetation of Spectacle island, Hawkesbury River, New South Wales. *Cunninghamia* 1(1): 115-119.
- Wilson, E. (ed.) (1986) *Discovering the Domain*. (Hale & Iremonger: Sydney).
- Woolls, W. (1891) *Plants indigenous and naturalised in the neighbourhood of Sydney*. (Government Printer: Sydney).
- Worgan, G.B. (1978) *Journal of a First Fleet surgeon*. Publication No 16, The William Dixon Foundation. (The Library Council of New South Wales in association with Library of Australian History: Sydney).
- Workers' Educational Association Plant Ecology Group (1959) List of native plants (recorded in the Lake Parramatta Reserve). *Australian Wild Life* 3: 12-14.

Manuscript received 31 January 1994
Manuscript accepted 14 September 1994

Ecology of Sydney plant species

Part 2: Dicotyledon families Asteraceae to Buddlejaceae

Doug Benson and Lyn McDougall

Abstract

Benson, Doug and McDougall, Lyn (National Herbarium of New South Wales, Royal Botanic Gardens Sydney, Australia 2000) 1994. Ecology of Sydney plant species: Part 2: Dicotyledon families Asteraceae to Buddlejaceae. Cunninghamia 3(4) 789–995. Ecological data in tabular form is provided on 355 plant species, 187 native and 168 exotics, mostly naturalised, occurring in the Sydney region, defined by the Central Coast and Central Tablelands botanical subdivisions of New South Wales (approximately bounded by Lake Macquarie, Orange, Crookwell and Nowra). Families are Asteraceae, Avicenniaceae, Balsaminaceae, Basellaceae, Baueraceae, Berberidaceae, Bignoniaceae, Boraginaceae, Brassicaceae, Buddlejaceae.

Data is derived from herbarium collections, literature and field observations. It is hoped that the many, often alarming, gaps in the information available will stimulate much-needed research into the ecology of more of the species. Information is provided so far as available to us for each plant species in the following categories:

Life History: Growth form, vegetative spread, longevity, primary juvenile period (time from germination to fruiting), reproduction, flowering and fruiting times, fruit/seed type, dispersal, establishment and growth, fire response, interaction with other organisms.

Distribution: Status/origin (native/naturalised), botanical subregions, distribution in Sydney area, selected locations.

Habitat: Habitat, altitude, annual rainfall, typical local abundance, vegetation, substrate, exposure.

Conservation: Conservation status.

Introduction

The *Ecology of Sydney Plant Species* aims to provide ecological information on native and naturalised Sydney plants. Particular emphasis has been given to data that is relevant for ecologists and natural area managers, for people involved in bush regeneration, land rehabilitation and landscape design, for researchers in many fields and for a wide range of people who are interested in bushland and native plants. Species-specific information is also relevant to environmental impact assessment and to studies involving changes in drainage, water movement, wind exposure, nutrient conditions and fire regimes on plant species and plant communities. Information included covers growth form, flowering and fruiting times, longevity and maturity periods; pollination and seed dispersal data, distribution, habitat and

plant community, as well as responses to fire and disturbance where available, and is largely complementary to the descriptive texts in taxonomic handbooks such as the *Flora of New South Wales* (Harden 1990–93).

Part 2 of the *Ecology of Sydney Plant Species* covers Dicotyledon families alphabetically from Asteraceae to Buddlejaceae. Families covered are Asteraceae, Avicenniaceae, Balsaminaceae, Basellaceae, Baueraceae, Berberidaceae, Bignoniaceae, Boraginaceae, Brassicaceae, Buddlejaceae. A total of 355 plant species are included, 187 native and 168 exotics, mostly naturalised. Species for which we have good ecological data include *Avicennia marina*, *Raphanus raphanistrum*, *Cirsium vulgare*, *Chrysanthemoides monilifera*, *Chondrilla juncea* and *Xanthium spinosum*. For the majority of species, the presentation of our current knowledge shows many, often alarming, gaps in the information available. It is hoped that making the situation better known will stimulate much-needed and wide ranging research into the ecology of many more of these species.

Methods

Part 2 follows the format used in *Part 1 — Ferns, fern allies, cycads, conifers and Dicotyledon families Acanthaceae to Asclepiadaceae* (Benson & McDougall 1993). The Sydney region is defined as the Central Coast and Central Tablelands botanical subdivisions (i.e. approximately bounded by Lake Macquarie, Orange, Crookwell and Nowra) (Figure 1). This is the area broadly covered by *Flora of the Sydney Region* (Carolin & Tindale 1993), with the exception that the Hunter Valley is not included here since it lies within the North Coast and Central Western Slopes subdivisions.

The Sydney region includes approximately 3500 plant species, both native and naturalised. To deal effectively with this number, the work has been divided into parts each of approximately 350 species based on plant families beginning with ferns, Cycads and Gymnosperms, and then Dicotyledon and Monocotyledon families. Within these groups, families, genera and species are arranged alphabetically:

- Part 1:** Ferns, Fern allies, Cycads and Conifers
Dicotyledon families Acanthaceae to Asclepiadaceae
- Part 2:** Dicotyledon families Asteraceae to Buddlejaceae
- Part 3:** Cabombaceae to Eupomatiaceae
- Part 4:** Fabaceae
- Part 5:** Flacourtiaceae to Myrsinaceae
- Part 6:** Myrtaceae
- Part 7:** Nyctaginaceae to Rubiaceae
- Part 8:** Rutaceae to Zygophyllaceae
- Part 9:** Monocotyledon families
- Part 10:** Monocotyledon families

For each species (and generally for subspecies) a data sheet is prepared incorporating life history, distribution and habitat data from specimens in the National Herbarium of New South Wales and this information is entered in a database. To this are added data from literature sources both published and unpublished. References have been cited as appropriate but for unreferenced data responsibility has been assumed by the authors. A provisional compilation sheet with the available information is then prepared and distributed to interested persons for comments and additions/alterations. This compilation is then published in parts in *Cunninghamia*, with the subsequent long-term aim of producing a book at the completion of the ten parts. This will allow the incorporation of new and additional material.

Information categories

For each species or subspecies, information is presented under headings relating to different life-history aspects, each with further subdivisions. Emphasis has been given to understanding the species in its wild habitat. For this reason data on cultivation and artificial propagation, available in horticultural books, is generally not included. Likewise, information on weed control is not given. Otherwise, however, the categories are broadly interpreted and since an aim of the project is to stimulate further investigation, we welcome the addition of extra data on any other aspects of the plants' ecology.

Botanical nomenclature

Family/Genus/Species: Names currently recognised at the National Herbarium of New South Wales and mostly as used in *Flora of New South Wales*.

Common name: Names used in *Flora of New South Wales*.

Life history

Growth form: Brief description.

Source: *Flora of New South Wales*.

Vegetative spread: Indication of whether localised expansion or spread is possible from an individual by rhizome, stolon, rootsucker etc. Important in determining ability of species to colonise immediate local area. Does not include vegetative distance dispersal which is included under Establishment & Growth (diaspore).

Source: Flora descriptions, Herbarium specimens, field observations.

Longevity: Average potential life-span under natural conditions — range in years where possible, indefinite, where death is not a result of inherent growth e.g. continued rhizomatous growth. Longevity may be shorter in cultivation.

Source: Literature, authors' assessment from field observations.

Primary juvenile period: time taken from germination to produce first fruits or spores (Gill [1975] uses the term for the period from germination to flowering but

the period to fruit maturity is more significant ecologically). Secondary juvenile period is the time taken for an individual to recover to produce fruit after major damage e.g. from fire, but applicable only if the species regularly resprouts.

Source: Literature, field observations.

Reproduction: For Angiosperms, Reproduction separated into:

Flowers: flower colour, flowering period — range of months and, where possible, peak month based on frequency of herbarium collections. Pollination vectors.

Fruit: fruit shape and size, particularly with respect to potential dispersal agents. Maturation period. Seed size and number.

Source: Herbarium specimens, field observations, *Flora of New South Wales*, literature.

Establishment and growth: Diaspore type (including vegetative), dispersal agent. Germination requirements: seedbank presence, dormancy, growth rates, seasonality, deciduousness etc. [notes on propagation in cultivation may be given where these imply similar behaviour under natural field conditions e.g. insights into seed germination inhibition].

Source: Literature, field observations.

Fire response: General response of mature plant to fire, in particular whether it generally resprouts or is killed (see also Gill 1981, Gill & Bradstock 1992). Seedling recruitment associated with fire is included under establishment and growth.

Source: Field observations, literature.

Interaction with other organisms: Symbiosis, predators, diseases etc.

Source: Mainly literature.

Distribution

Status/origin: native or naturalised, region of origin, source and date of introduction/naturalisation

Source: *Flora of New South Wales*, literature.

Botanical subregions: occurrence of species in botanical subdivisions of N.S.W., other states and countries.

Source: National Herbarium of New South Wales.

Distribution in Sydney area: Main geographic regions occupied by species.

Source: Herbarium specimen records.

Selected locations: restricted to about 10 localities for each taxon reflecting natural geographical range of species in the Sydney area. Earliest collection dates are given for some species, particularly exotic species. Recent collection sites indicated where possible. Locality data must be interpreted carefully. The record may be based on an old specimen or observation record and the species may no longer be present at the site. However a knowledge of the original distribution may be important in showing up particular habitat requirements of the species.

Source: Herbarium specimen records.

Habitat

Specific data refers to Sydney area unless stated otherwise.

Habitat: Brief generalised description.

Source: Herbarium specimen records, field observations.

Altitude: Approximate altitudinal range (m +/- 100 m) occupied by the species.

Source: Herbarium specimen records.

Annual rainfall: Approximate annual rainfall range (mm +/- 100 mm) for sites occupied by the species.

Source: Bureau of Meteorology (1975, 1979).

Typical local abundance: Most frequent recordings (scale: dominant/frequent/occasional/rare).

Source: Herbarium specimen records.

Vegetation: Main structural type with typical associated species where available.

Source: Herbarium specimen records, field observations, literature.

Substrate: Geology, soil, moisture supply.

Soil nutrient rating scale: Very fertile (e.g. basalt soils)/fertile/infertile/very infertile (e.g. sands).

Soil water-table scale: permanently high/mostly high/mostly low/permanently low.

Soil salinity scale: Hypersaline/saline/brackish/fresh.

Source: Herbarium specimen records, field observations, literature.

Exposure:

Exposure scale: Exposed/indifferent/sheltered.

Shading scale: Deep shade/mid shade/light shade/no shade.

Source: Herbarium specimen records, field observations, literature.

Conservation

Conservation: National significance listing (Briggs & Leigh 1988), regional significance and adequacy of conservation within Sydney area where available.

Source: Herbarium records, field observations, literature.

General comments on Part 2

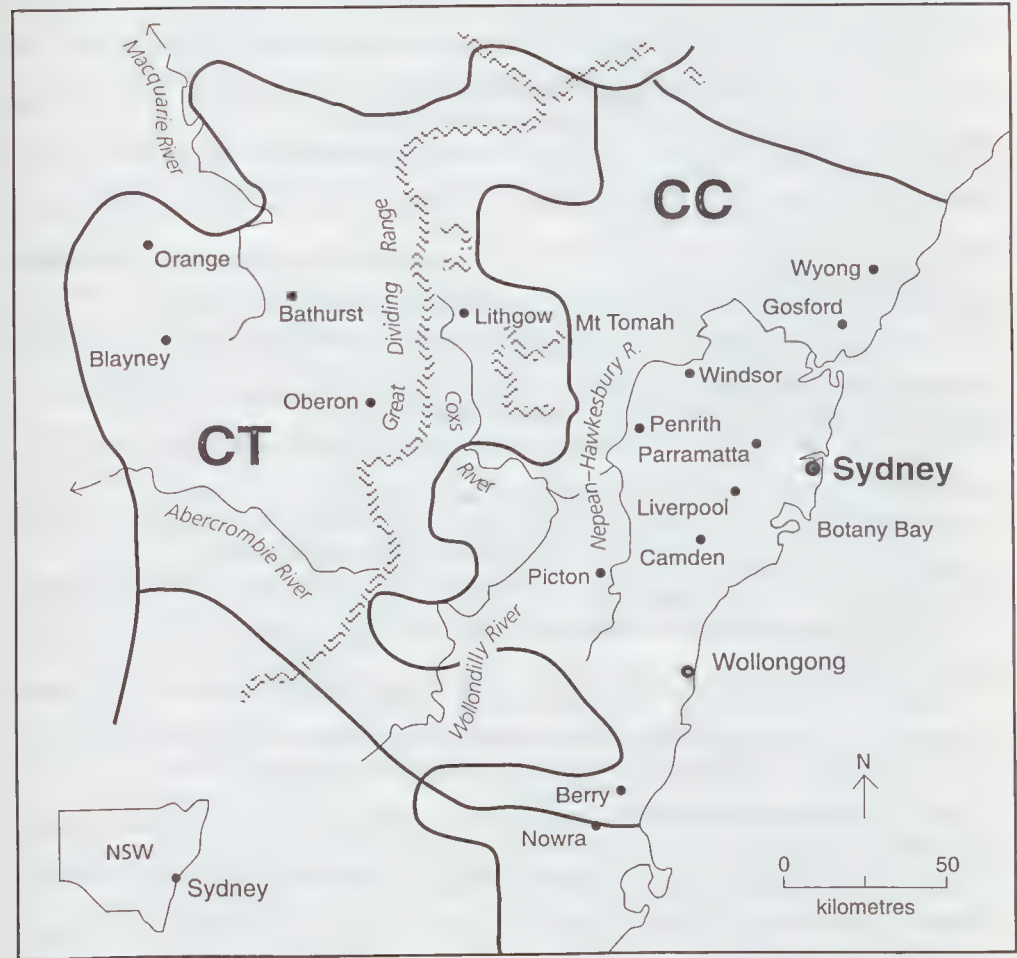
The majority of this part covers the family Asteraceae. There are 270 species of Asteraceae, 41% of which are exotic. Some of these are major agricultural weeds and it is these weed species, e.g. *Cirsium vulgare*, *Chondrilla juncea*, that are the best known ecologically. There has been virtually no serious ecological study of any of the native species. A few endangered species, e.g. *Olearia cordata*, have been the subject of Recovery Plans, but these are only based on general survey work with little intensive follow-up. Many of the Asteraceae are relatively inconspicuous or uncommon and

tend to be overlooked. Little appears to be known on many of the shrubby Asteraceae, although many are well represented in the Sydney area in a range of habitats from rainforest to heath. Of the 51 NSW species of *Olearia*, 23 occur in the Sydney area, as well as 15 out of 45 *Brachycome* species and 9 out of 14 *Vittadinia* species. These species do not have conspicuous fire responses like Proteaceae and Myrtaceae, although this itself may be a valid reason for studying them. Many may be short-lived and important in colonising disturbed sites and may have potential for land rehabilitation projects. Yet we have little data in regard to dispersal, growth rates or colonising behaviour, pollination vectors and propagule dispersal mechanisms.

Similar comments apply to the other families in this Part. Longevity of species, apart from annuals, is rarely noted. Data on fire responses are available for common, conspicuous species but not for the smaller, less obvious species. The conservation status of many species is unknown. Collections from the early 1900s suggest that many Asteraceae appear to have been widespread in the Sydney area but are now much more restricted. Because they are not conspicuous their disappearance has not been noted, but species like *Cassinia uncata*, *Cassinia longifolia* and *Ozothamnus adnatus*, previously recorded in the Sydney suburban area, have not survived well in urban bush reserves, either because of more mobile populations or because they required the higher-nutrient soils that were subsequently cleared. For the many exotic weed species other than those of concern to agriculture, we have only limited knowledge of their current distributions and little idea of whether they are stable or becoming potential problems. Quite a number of species have only been recorded since the 1960s and may be spreading e.g. *Acanthospermum australe*, *Leontodon taraxicoides* subsp. *taraxicoides*, *Senecio pterophorus* and *Baccharis halimifolia*. For other exotic species there is virtually no data from local sources — some of these are based on only one or a few old records and may now be extinct in the region e.g. *Ambrosia artemisiifolia*.

Acknowledgements

The authors wish to particularly thank Paul Adam, Barbara Briggs, Elizabeth Brown, Robin Buchanan, Carrick Chambers, Michael Clarke, Peter Clarke, Robert Coveny, Joy Everett, Fang Wang, Gwen Harden, David Hardin, Ken Hill, Jocelyn Howell, Lawrie Johnson, David Keith, Phillip Kodela, Poul Kubiak, Nicholas Lander, Alan Leishman, Maria Matthes, Malcolm Reed, Tony Rodd, Mark Robinson and Peter Wilson for advice and information, and The Royal Botanic Gardens and Domain Trust for financial support.



The Sydney region

For this work the Sydney region is defined as the Central Coast and Central Tablelands botanical subdivisions.

References

- Allaway, W.G. (1982) Mangrove die-back in Botany Bay. *Wetlands (Australia)* 2 (1): 2-7.
- Anon (1991) Appendix 10. In *Plant invasions the incidence of environmental weeds in Australia. Kowari 2* (Australian National Parks & Wildlife Service: Canberra).
- Armstrong, J.A., Powell, J.M. & Richards, A.J. (1982) *Pollination and evolution* (Royal Botanic Gardens: Sydney).
- Barker, R.D. & Vestjens, W.J.M. (1989) *The food of Australian birds. Vol. 1* (CSIRO Australia: Melbourne).
- Barker, R.D. & Vestjens, W.J.M. (1990) *The food of Australian birds. Vol. 2* (CSIRO Australia: Melbourne).
- Bass, D.J. (1987) Weeds and human health (Department of Allergy, Royal North Shore Hospital: St Leonards, unpub.).
- Bass, D.J. & Wrigley, C.W. (1984) Pollen allergens around Australia: a survey of clinician's experience. *The Medical Journal of Australia, special supplement*.
- Benson, D.H. (1981) Vegetation at Agnes Banks sand deposit, Richmond, New South Wales. *Cunninghamia* 1(3): 35-57.
- Benson, D.H. & Keith, D.A. (1990) The natural vegetation of the Wallerawang 1:100 000 map sheet. *Cunninghamia* 2(2): 305-335.
- Benson, D.H. & McDougall, L. (1991) *Rare bushland plants of western Sydney* (Royal Botanic Gardens: Sydney).
- Blackwell, W. H. (1990) *Poisonous and medicinal plants* (Prentice Hall: New Jersey).
- Briggs, J.D. & Leigh, J.H. (1988) *Rare or threatened Australian plants*. Special publication No. 14 (Australian National Parks and Wildlife Service: Canberra).
- Buchanan, R.A. (1989) *Bush regeneration: recovering Australian landscapes* (TAFE: Sydney).
- Burbidge & Gray (1976) *Flora of the ACT* (ANU Press: Canberra).
- Bureau of Meteorology (1975) *Climatic averages: New South Wales* (Australian Govt. Pub. Service: Canberra).
- Cambie, R.C. & Ash, J. (1994) *Fijian medicinal plants* (CSIRO Australia: Melbourne).
- Campbell, M.H., McGowen, I.J., Milne, B.R. & Vere, D.T. (1990) The Biology of Australian Weeds 22. *Cassinia arcuata* R.Br. *Plant Protection Quarterly* 5(4) 162-168.
- Carolin, R.C. & Tindale, M. D. (1993) *Flora of the Sydney region*. Fourth Edition (Reed: Chatswood).
- Carr, G.W., Yugovic, J.V. & Robinson, K.E. (1992) *Environmental weed invasions in Victoria: conservation and management implications* (Dept. of Conservation & Environment: East Melbourne).
- Cheam, A.H. (1984a) Coat-imposed dormancy controlling germination in wild radish and fiddle dock seeds. *Proceedings 7th Australian Weeds Conference* 184-90.
- Cheam, A.H. (1986a) Seed production and seed dormancy in wild radish (*Raphanus raphanistrum* L.) and some possibilities for improving control. *Weed Research* 26: 405-13.
- Ciba-Geigy (1968-) *Weed Tables* (Ciba-Geigy: Basel).
- Clarke, P.J. (1989) Coastal plants of New South Wales. *Technical report No. 22* (Soil Conservation Service of NSW: Sydney).
- Clarke, P.J. (1992) Predispersal mortality and fecundity in the grey mangrove (*Avicennia marina*) in south eastern Australia. *Australian Journal of Ecology* 17: 161-168.
- Clarke, P.J. (1993) Dispersal of grey mangrove (*Avicennia marina*) propagules in southeastern Australia. *Aquatic Botany* 45: 195-204.
- Clarke, P.J. (1994) Baseline studies of temperate mangrove growth and reproduction; demographic and letterfall measures of leafing and flowering. *Australian Journal of Botany* 42: 37-48.
- Clarke, P.J. (1994) The population dynamics of the mangrove *Avicennia marina*; demographic synthesis and predictive modelling. *Hydrobiologia* (in press).
- Clarke, P.J. & Allaway, W.G. (1993) The regeneration niche of the grey mangrove (*Avicennia marina*): effects of salinity, light and sediment factors on establishment, growth and survival in the field. *Oecologia* 93: 548-556.
- Clarke, P.J. & Myerscough, P.J. (1991) Buoyancy of *Avicennia marina* propagules in south-eastern Australia. *Australian Journal of Botany* 39: 77-83.
- Clarke, P.J. & Myerscough, P.J. (1991) Floral biology and reproductive phenology of *Avicennia marina* in south eastern Australia. *Australian Journal Botany* 39: 283-93.

- Clarke, P.J. & Myerscough, P.J. (1993) The intertidal distribution of the grey mangrove (*Avicennia marina*) in southeastern Australia: the effects of physical conditions, interspecific competition, and predation on propagule establishment and survival. *Australian Journal of Ecology* 18: 307–315.
- Code, G.R., Walsh, M.J. and Reeves, T.G. (1987) Effect of depth and duration of burial of wild radish seed on seed viability and seedling emergence. In *Weed seed biology*. Proceedings of working papers of a workshop approved by Standing Committee on Agriculture, Orange NSW.
- Collins, D.J., Culvenor, C.C.J., Lamberton, J.A., Loder, J.W., & Price, J.R. (1990) *Plants for medicines*. (CSIRO: Melbourne).
- Colton, R.T. (1988) Safflower growing. *Agfact* P5.2.2 (NSW Agriculture: Sydney).
- Commens, C.A., Bartlett, B.H., McGeoch, A.H. & Kossard, S. (1982) Bindii (Jo Jo) dermatitis the clinical and histopathological spectrum. *Australian Journal of Dermatology* 23: 110–115.
- Common, I.F.B. (1990) *Moths of Australia* (Melbourne University Press: Collingwood).
- Common, I.F.B. & Waterhouse, D.F. (1982) *Butterflies of Australia: field edition* (Angus & Robertson: Sydney).
- Coupar, P. & Coupar, M. (1992) *Flying colours, common caterpillars, butterflies and moths of south-eastern Australia* (New South Wales University Press: Kensington).
- CSIRO Division of Entomology. *Biological control of nodding thistle Carduus nutans* (CSIRO Australia).
- Culvenor, C.C.J. (1985) Paterson's curse and toxic alkaloids. *Search* 16: 219.
- Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. & Leigh, J.H. (1981) *Plants of western New South Wales* (Government Printer: Sydney).
- Davis, G. (1956) Revision of the genus *Podolepis* Labill. *Proceedings of Linnean Society of New South Wales* 382: 245–286.
- Dellow, J.J. (1989) *Amsinckia*: yellow burrweed. *Agfact* P7.6.12 (NSW Agriculture: Sydney).
- Doing, H., Biddiscombe, E.F. & Knedlhans, S. (1969) Ecology and distribution of the *Carduus nutans* group (nodding thistles) in Australia. *Vegetatio* 17: 313–351.
- Dyason, R. (1986) Crofton Weed. *Agfact* P7.6.36 (NSW Agriculture: Sydney).
- Everist, S. L. (1974) *Poisonous plants of Australia* (Angus & Robertson: Sydney).
- Fallding, H. & Benson, J.S. (1985) Natural vegetation and settlement at Macquarie Pass, Illawarra region, New South Wales. *Cunninghamia* 1(3): 285–311.
- Field, R. & Kannangara, H.W. (1987) Biological and environmental factors influencing the germination and establishment of Yarrow (*Achillea millefolium* L.) In *Weed seed biology*. Proceedings of working papers of a workshop approved by Standing Committee on Agriculture, Orange NSW.
- Floyd, A.G. (1983) N.S.W. rainforest trees: part 12. *Forestry Commission of New South Wales Research Note* No. 49.
- Floyd, A.G. (1989) *Rainforest trees of mainland south-eastern Australia* (Inkata Press: Sydney).
- Fox, M.D. (1988) Understorey changes following fire at Myall Lakes, New South Wales. *Cunninghamia* 2(1): 85–95.
- Gill, A.M. (1975) Fire and the Australian flora: a review. *Australian Forestry* 38: 4–25.
- Gill, A.M. (1981) Adaptive responses of Australian vascular plant species to fires. Chapter 11 in *Fire and the Australian biota* (A.M. Gill, R.H. Groves, I.R. Noble Eds) (Australian Academy of Science: Canberra).
- Gill, A.M. & Bradstock, R.A. (1992) A national register for the fire responses of plant species. *Cunninghamia* 2 (4): 653–660.
- Gorham, P. (1986) Saffron Thistle. *Agfact* P7.6.34 (NSW Agriculture: Sydney).
- Grant, D.L., Clarke, P.J. & Allaway, W.G. (1993) The response of grey mangrove (*Avicennia marina* (Forsk.) Vierh.) seedlings to spills of crude oil. *J. Exp. Mar. Biol. Ecol.* 171: 273–295.
- Häfliger, T.J. (1988) *Dicot Weeds* (Ciba-Geigy: Basel).
- Hamilton, A.A. (1919) An ecological study of the saltmarsh vegetation in the Port Jackson district. *Proceedings of the Linnean Society of New South Wales* 44: 463–513.
- Harden, G.J. (Ed.) (1990–3) *Flora of New South Wales* Vol. 1–4 (New South Wales University Press: Kensington).
- Heyligers (1983) An appraisal of the Beach Daisy (*Arctotheca populifolia*) with a view to its possible use for dune stabilization. *The Victorian Naturalist* 100: 48–54.
- Holtkamp, R. & Hosking, J. (1993) Insects and diseases of fireweed, *Senecio madagascariensis*. *Agnote* 2/091 (NSW Agriculture & Fisheries: Sydney).

- Hurst, E. (1942) *The poison plants of New South Wales* (The poison plants committee of University of Sydney & NSW Department of Agriculture).
- Jones, D. & Elliot, R. (1986) *Pests diseases and ailments of Australian plants* (Lothian: Port Melbourne).
- Keith, D.A. & Benson, D.H. (1988) The natural vegetation of the Katoomba 1:100 000 map sheet. *Cunninghamia* 2: 107–143.
- Klinkhamer, P.G. & De Jong, T.J. (1993) *Cirsium vulgare* (Savi) Ten. (*Carduus lanceolatus* L., *Cirsium lanceolatum* (L.) Scop., non Hill). *Journal of Ecology* 81: 177–191.
- Kodala, P.G. & Foster, D.A. (1990) Common plants and soil salinity in the Lower Boro area, Southern Tablelands, New South Wales. *Cunninghamia* 2(2): 217–222.
- Kodala, P.G., James, T.A., Coveny, R.G. & Hind, P.D. (1992) Reconnaissance survey of the vegetation at Long Swamp, near Penrose, Central Tablelands, NSW (Royal Botanic Gardens Sydney, unpub.).
- Lamp, L. & Collet, F. (1989) *Field guide to weeds in Australia* (Inkata Press: Melbourne).
- Lander, N.S. (1991) New taxa and new combinations in *Olearia* (Asteraceae: Astereae) from south-eastern Australia. *Telopea* 4(2): 145–164.
- Langkamp, P.J. (Ed.) (1987) *Germination of Australian native plant seed* (Inkata Press: Melbourne).
- Leigh, J.H., Wimbush, D.J., Wood, D.H., Holgate, M.D., Slee, A.V., Stanger, M.G. & Forrester, R.I. (1987) Effects of rabbit grazing and fire on a subalpine environment. *Australian Journal of Botany* 35: 433–64.
- Lepschi, B.J. (1993) Food of some birds in eastern New South Wales: additions to Barker & Vestjens. *Emu* 93:195–199.
- Lawrence, M.E. (1985) *Senecio* L. (Asteraceae) in Australia: reproductive biology of a genus found primarily in unstable environments. *Australian Journal of Botany* 33: 197–208.
- Low, T. (1990) *Bush medicine, a pharmacopoeia of natural remedies* (Angus & Robertson: Sydney).
- McBarron, E.J. (1983) *Poisonous plants: handbook for farmers and graziers*. Department of Agriculture New South Wales (Inkata Press: Melbourne).
- McGowen, I.J., Campbell, M.H. & Milne, B.R. (1990) Sifton bush (biddy bush, Chinese shrub). *Agfact* P7.6.49 (NSW Agriculture & Fisheries: Sydney).
- McLoughlin, L. & Rawling, J. (1990) *Making your garden bush friendly: how to recognise and control garden plants which invade Sydney's bushland*. (McLoughlin-Rawling: Killara).
- Medd, R.W. (1984) Nodding thistle. *Agfact* P7.6.28 (NSW Agriculture: Sydney).
- Mill, R.R. (1989) The taxonomic status of *Cynoglossum latifolium* (Boraginaceae). *Notes of Royal Botanic Gardens Edinburgh* 46: 43–47.
- Mills, K. (1988) *Conservation of rainforest plant species, Illawarra region of NSW. inventory, assessment and recommendations for management* (NSW National Parks and Wildlife Service: Hurstville).
- Milvain, H. (1983) Noogoora Burr and Californian Burr. *Agfact* P7.6.23 (NSW Agriculture: Sydney).
- Milvain, H. (1991) Bathurst Burr. *Agfact* P7.6.14 (NSW Agriculture: Sydney).
- Mitchell, A.S. (1988) Blue and common heliotrope. *Agfact* P7.6.45 (NSW Agriculture and Fisheries: Sydney).
- Nelson, N.R. & Michael, P.W. (1982) Germination and growth of *Senecio madagascariensis* Poir. (fireweed), a toxic plant of pastures in coastal New South Wales. *Proceedings 2nd Australian Agronomist Conference*: 173.
- Parsons, W.T. (1973) *Noxious weeds of Victoria* (Inkata Press: Melbourne).
- Parsons, W.T. & Cuthbertson, E.G. (1992) *Noxious weeds of Australia* (Inkata Press: Melbourne).
- Payne, (1970) Flora of Wisconsin No. 62. *Wisconsin Academy of Sciences, Arts & Letters* 58: 364–366.
- Piggin, C.M. (1976) Factors affecting seed germination of *Echium plantagineum* L. and *Trifolium subterraneum* L. *Weed Research* Vol. 16, 337–344.
- Piggin, C.M., Reeves, T.G., Brooke, H.D. & Code, G.R. (1978) Germination of wild radish (*Raphanus raphanistrum* L.). *Proceedings 1st conference of the Australian Weed Science Society*: 233–40.
- Popay, I. (1987) Weed seed biology of some New Zealand pasture weeds. In *Weed seed biology. Proceedings of working papers of a workshop approved by Standing Committee on Agriculture, Orange NSW*.
- Price, D. (1963) Calendar of flowering times of some plants of the Sydney district, possibly associated with pollinosis. *Contributions from the National Herbarium of NSW* 3: 171–194.
- Purdie, R.W. (1977) Early stages of regeneration after burning in dry sclerophyll vegetation: I Regeneration of the understorey by vegetative means. *Australian Journal of Botany* 25: 21–34.

- Reeves, R.G., Code, G.R., & Piggin, C.M. (1981) Seed Production and longevity, seasonal emergence, and phenology of wild radish (*Raphanus raphanistrum* L.). *Australian Journal of Experimental Agriculture & Animal Husbandry* 21: 524-30.
- Rice, B. & Westoby, M. (1981) Myremecochory in sclerophyll vegetation of the West Head, New South Wales. *Australian Journal of Ecology* 6: 291-298.
- Rodman, J. E. (1986) Introduction, establishment and replacement of sea-rockets (*Cakile*, *Cruciferae*) in Australia. *Journal of Biogeography* 13: 159-171.
- Scurfield, G. (1962) *Cardaria draba* (L.) Desv. (*Lepidium draba* L.) Biological flora of the British Isles. *Journal of Ecology* 50: 489-499.
- Semple, W.S. (1993) Native and naturalised plants of some saline sites in the central west of NSW. *Technical Report No. 31* (Department of Conservation and Land Management: Sydney).
- Short, P.S. (1988) Two new species of *Brachyscome* Cass. (Compositae: Asteraceae), with a note on the orthography of the generic name. *Muelleria* 6: 389-398.
- Sindel, B.M. (1986) The ecology and control of fireweed (*Senecio madagascariensis* Poir.) *Plant Protection Quarterly* 1: 163-72.
- Sindel, B.M. (1987) Competition between fireweed, *Senecio madagascariensis* and oats, *Avena strigosa*. *Proceedings of 8th Australian Weeds Conference*: 171-174.
- Sindel, B.M. (1989) The ecology and control of fireweed (*Senecio madagascariensis* Poir.). Ph.D. thesis, University of Sydney.
- Sindel, B.M. & Michael, P.W. (1988) Survey of the impact and control of fireweed (*Senecio madagascariensis* Poir.) in New South Wales *Plant Protection Quarterly* 3: 22-28.
- Sindel, B.M. & Michael, P.W. (1989) Frost as a limiting factor in the distribution of *Senecio madagascariensis* Poir. (fireweed) in Australia. *Proceedings 12th Asian-Pacific Weed Science Society Conference*: 453-459.
- Sindel, B.M. & Michael, P.W. (1992) Spread and potential distribution of *Senecio madagascariensis* Poir. (fireweed) in Australia. *Australian Journal of Ecology* 17: 21-26.
- Southcott, R.V. & Haegi, L.A.R. (1992) General Practice: Garden hazards, plant hair dermatitis. *Medical Journal of Australia* 156: 623-632.
- State Pollution Control Commission (n.d.) *A guide to mangrove transplanting* (NSW Agriculture: Sydney).
- Sulman, F. (1914) *A popular guide to the wildflowers of NSW Vol. 2* (Angus & Robertson: Sydney).
- Tanner, L. R. (Ed.) (1993) *Proceedings of the seventh biennial noxious plants conference Vol. 1* (NSW Agriculture: Tamworth).
- Turkington, R. & Aarssen, L.W. (1983) Biological flora of the British Isles: *Hypochoeris radicata* L. *Journal of Ecology* 71: 999-1022.
- Van der Valk, A.G. & Attiwill, P.M. (1984) Decomposition of leaf and root litter of *Avicennia marina* at Western port Bay, Victoria, Australia. *Aquatic Botany* 18: 205-221.
- Watson, R., Launder, T. & Macadam, J. (1984) Fireweed. *Agfact* P7.6.26 (NSW Agriculture: Sydney).
- West, J.G. (1984) A revision of *Dodonaea* Miller (Sapindaceae) in Australia. *Brunonia* 7:1-94.
- West, R.J. (1985) Mangroves. *Agfact* F2.0.1 (NSW Agriculture & Fisheries: Sydney).
- Westoby, M., Rice, B. & Howell, J. (1990) Seed size and plant growth form as factors in dispersal spectra. *Ecology* 71: 1307-1315.
- Willis, A.J. & Groves, R.H. (1991) Temperature and light effects on the germination of seven native forbs. *Australian Journal of Botany* 39: 219-28.
- Wilson, P.G. (1990) *Halgania brachyrhyncha* (Boraginaceae), a new species from eastern Australia. *Telopea* 4(1).

Dicotyledon families Asteraceae to Buddlejaceae

Acanthospermum australe *

ASTERACEAE

Life history

Growth form: Prostrate herb with stems to 60 cm long and opposite leaves.

Vegetative spread:

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: White, summer.

Fruit/seed: Achene 7–9 mm long with prickles, mature December–March.

Dispersal, establishment & growth: Diaspore: fruit, probably mammal-dispersed, ? human.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to America.

Botanical subregions: NC CC.

Distribution Sydney area: Coastal, mainly eastern suburbs of Sydney.

Select locations: Malabar (1967), Little Bay, Matraville, La Perouse, Garie Beach (1987).

Habitat

Habitat: Roadsides and lawns.

Altitude: 0–100 m **Annual rainfall:** above 1200 mm

Typical local abundance: Occasional.

Vegetation: With other roadside weeds e.g. *Oenothera indecora*. Ground stratum.

Substrate: Sandy, infertile soils. Watertable permanently low; moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Recently recorded weed that may be spreading along coast.

Achillea distans subsp. *tanacetifolia* *

ASTERACEAE

Tansyleaf Milfoil

Life history

Growth form: Herb to 120 cm high, with rhizome.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Whitish, pink or red with yellow disc, spring–summer.

Fruit/seed: Achene 1.5–2.5 mm long, no pappus.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe. Introduced as an ornamental and may occur as a garden escape.

Botanical subregions: CC SC NT ST; Qld, NT.

Distribution Sydney area: Only record Leichhardt.

Select locations: Leichhardt (1941).

Habitat

Habitat:

Altitude: 0–100 m

Annual rainfall: 1200 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Rare, only 1 record, probably not naturalised in the area.

***Achillea millefolium* ***

ASTERACEAE

Yarrow

Life history**Growth form:** Stoloniferous herb 10–100 cm high.**Vegetative spread:** Regrows from rhizome fragments (Field & Kannangara 1987).**Longevity:** Perennial.**Primary juvenile period:****Flowers:** White–pink, disc yellow, November–April.**Fruit/seed:** Achene to 3 mm long, no pappus. Seeds small 160 µg (Field & Kannangara 1987).**Dispersal, establishment & growth:** Wind-dispersed (Carr et al. 1992). Eight month old stand produced 243,000 seeds per m²; requires light for germination — seed at or near the soil surface germinates rapidly; seed viability increases with soil depth — estimated survival of seed buried at 32 cm is 17 years (Field & Kannangara 1987).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe.**Botanical subregions:** NC SC NT CT ST SWS; Vic.**Distribution Sydney area:** Upper Blue Mountains and west of the area.**Select locations:** Mt Wilson (1896), Katoomba, Lett River, Lithgow, Orange, Milthorpe.**Habitat****Habitat:** Roadside weed.**Altitude:** above 800 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Ground stratum.**Substrate:** Basalt soil, very fertile. Watertable permanently low, moisture supply intermittent, fresh.**Exposure:****Conservation****Conservation:** Roadside weed.***Actites megalocarpa* (Sonchus megalocarpus)**

ASTERACEAE

Dune Thistle

Life history**Growth form:** Fleshy herb to 40 cm high, responds to sand accumulation by vertical growth.**Vegetative spread:** Forms large clumps by creeping rhizome.**Longevity:** Indefinite.**Primary juvenile period:** 1 year (Clarke 1989).**Flowers:** Yellow, sometimes pale purple towards the base, September–May.**Fruit/seed:** Achene 4–8 mm long with pappus of bristles 7–13 mm long, matures September–May.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed, vegetative multiplication absent; seedlings sun-tolerant, wind-tolerant; adults wind-tolerant, drought-tolerant (Clarke 1989). Adults tolerant of salinity, secondary sand coloniser.**Fire response:** Unlikely to be burnt.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:****Select locations:** North Avoca, Wamberal, Palm Beach, Narrabeen, Manly, Bondi, Lady Robinson's Beach (1887), Cronulla, Shoalhaven Heads.**Habitat****Habitat:** Coastal sand dunes and cliffs, on the incipient foredune and the foredune.**Altitude:** 0–20 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Occasional.

Vegetation:

Substrate: Beach sand dunes, infertile, tolerant of underdeveloped soils.

Exposure: Exposed to salt-laden sea breezes, full sun.

Conservation

Conservation: Most herbarium records are pre- 1950. Possibly now less common than previously due to loss of habitat.

Adenostemma lavenia* var. *lavenia**ASTERACEAE**

Sticky Daisy

Life history

Growth form: Semi-prostrate or erect herb 0.3–1 m high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: White, spring–early summer.

Fruit/seed: Achene 2–4 mm long, with pappus of bristles 1 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld, N.T., Asia.

Distribution Sydney area: Chiefly north from Bulahdelah, with an old record from Botany Bay (Harden 1992).

Select locations: No CC specimens in Herbarium.

Habitat

Habitat: Damp, shaded places (Harden 1992).

Altitude: 0–100 m

Annual rainfall: above 1200 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Botany Bay southern limit, but now probably extinct in area.

Ageratina adenophora* **ASTERACEAE**

Crofton Weed

Life history

Growth form: Herb, with purplish, woody stems 1–2 m high from underground crown; short, thick rootstock has carrot-like odour when broken (Parsons & Cuthbertson 1992).

Vegetative spread: Colonies increase in size when layering occurs; spread also occurs when pieces of root with portion of the crown attached take root (Parsons & Cuthbertson 1992).

Longevity: Perennial.

Primary juvenile period:

Flowers: White, spring, September–November.

Fruit/seed: Achene 1–2 mm long with pappus of hairs 3–4 mm long. 'Seeds' light (25,000 seeds/gm); mature plant can produce 10,000–100,000 seeds per year (Dyason 1986).

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed both locally and long distance. Also water-dispersed (M. Clarke pers. comm.). Dispersed in mud sticking to humans, animals, machinery and in agricultural produce, seeds germinate in light December–September, peak (more than 80% of viable seeds) in February and March; seedlings establish rapidly and if damaged are able to regenerate from the crown within 8 weeks of germination (Parsons & Cuthbertson 1992). Seedlings shade-tolerant, may be frost-sensitive. Coloniser.

Fire response: Stems killed, resprouts at ground level. Resprouted from base and flowered

within 33 weeks after high-intensity fire (1/1994) at Lane Cove and Narrabeen (P. Kubiak pers. comm.)

Interaction with other organisms: Suspected of poisoning but seedlings palatable to stock; biological controls (insect and fungus) have been introduced but are not highly effective (Dyason 1986). Unpalatable to cattle but horses eat it readily, and die; sheep or goats can eat it without harm if other pasture is available. Biological control effective using a combination of organisms (Parsons & Cuthbertson 1992). Current experimental work with fungus *Phaeoamularia* species at Royal Botanic Gardens (Wang Fang pers. comm. 1994).

Distribution

Status/origin: Naturalised exotic, native to C America. Introduced to Sydney c. 1875 from England where it had been grown as a 'stove ornamental', first collected as a garden escape in 1904 (Parsons & Cuthbertson 1992). Story from Lismore: Mayor Crofton on his deathbed said words to the effect of 'it wasn't me who introduced the plant, it was my next door neighbour' (M. Clarke pers. comm.).

Botanical subregions: NC CC; Qld, S.A.

Distribution Sydney area: Coastal, current southern limit Kiama.

Select locations: Morisset, Mooney Creek, Cheltenham, Lane Cove River (1918), Willoughby, Eastwood, Kurnell, Liverpool, Wollongong, Minnamurra Falls, Springwood.

Habitat

Habitat: Moist sites, disturbed areas, roadsides, creeklines. Steeply sloping, frost-free land (Parsons & Cuthbertson 1992).

Altitude: 0–400 m **Annual rainfall:** above 800 mm

Typical local abundance: Dominant.

Vegetation: Open areas—woodland and forest. Ground stratum.

Substrate: Sandstone and shale soils, fertile–infertile. Watertable permanently high—mostly high, moisture supply continuous–intermittent, fresh.

Exposure: Sheltered situations; mid–light shade. High growth-rate of seedlings in full sun, can tolerate considerable shade but die in full shade (Parsons & Cuthbertson 1992). Full sun if moisture available (M. Clarke pers. comm.).

Conservation

Conservation: Present in the Sydney area for more than 30 years and has spread rapidly there since the 1970s (Dyason 1986). Crofton weed control usually depends on correcting the drainage problem that allowed the weed to establish (McLoughlin & Rawling 1990). Major weed of moist sites in bushland. Declared noxious weed in many shires.

Ageratina riparia *

ASTERACEAE

Mist Flower

Life history

Growth form: Herb 0.3–1 m high, stems purplish, erect, or decumbent, often with adventitious roots.

Vegetative spread: Stems in contact with soil form new plants by rooting from nodes (L.McD.). Colonies increase in size and density by layering, forming a mat of interwoven stems (Parsons & Cuthbertson 1992).

Longevity: Indefinite.

Primary juvenile period:

Flowers: White, August–November.

Fruit/seed: Achene 1–2 mm long, with pappus of hairs 3–4 mm long, mature September–December. Mature plants produce 10,000–100,000 seeds per year (Parsons & Cuthbertson 1992).

Dispersal, establishment & growth: Diaspore: fruit. Wind-dispersed, both locally and long distances. Water-dispersed, in mud by humans and animals, and dispersed as stem fragments; seed germinates immediately, but only in light, best at temperatures of 25° C–15° C (Parsons & Cuthbertson 1992).

Fire response: Resprouted from base after high-intensity fire (1/1994) at Lane Cove, flowering within 34 weeks (P. Kubiak pers. comm.). Stems killed, resprouts at ground level (R. Buchanan pers. comm.).

Interaction with other organisms: May be toxic to stock; leachates from leaves and plant litter have an allelopathic effect on other plants (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Naturalised exotic, native to Central America; garden escape. Growing in Royal Botanic Gardens Sydney 1895 (Parsons & Cuthbertson 1992).

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Coastal, north from Berry.

Select locations: Gosford, Galston Gorge, Pennant Hills, Northbridge, Sydney (1906), Bellevue Hill, Royal NP, Albion Park, Macquarie Pass (P. Kodela pers. comm.), Jamberoo, Foxground.

Habitat

Habitat: Disturbed gullies and creek banks.

Altitude: 0–200 m **Annual rainfall:** above 1200 mm

Typical local abundance: Dominant–frequent.

Vegetation: Ground stratum. In or near rainforest, along creeks.

Substrate: Creeks and gullies in sand and amongst rocks, sandstone. Soil fertile–infertile. Watertable mostly high, moisture supply continuous, fresh.

Exposure: Sheltered. Shade deep–mid. Seedling very shade-tolerant (R. Buchanan pers. comm.).

Conservation

Conservation: A declared noxious weed in many shires, invading bushland along creeklines.

Ageratum houstonianum* **ASTERACEAE****Life history**

Growth form: Erect or decumbent herb 0.3–1 m high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Blue-mauve, most of the year.

Fruit/seed: Achene, 2 mm long, with pappus of awned scales 2–3 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Mexico; widespread in Central America. Garden escape, rarely naturalised.

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Coastal Sydney.

Select locations: Palm Beach (1961), Narrabeen Lake, Glenfield.

Habitat

Habitat: Roadside, paddocks, creek bank.

Altitude: 0–50 m **Annual rainfall:** above 800 mm

Typical local abundance: Rare.

Vegetation: Weedy sites.

Substrate: Probably clay soils.

Exposure:

Conservation

Conservation: Rarely naturalised in bushland.

Ambrosia artemisiifolia* **ASTERACEAE**

Annual Ragweed

Life history

Growth form: Shallow-rooted herb to 2 m high.

Vegetative spread: No.

Longevity: Annual.

Primary juvenile period: Less than 1 year.

Flowers: Summer–autumn. Wind-pollinated (Ciba-Geigy 1968–).

Fruit/seed: Nut-like involucre, achene retained inside, one per fruit. Seed may remain viable in soil for 40 years or more in US.A. (Payne 1970).

Dispersal, establishment & growth: Dispersed by wind, water, animals and humans (with red clover seed from US); germinates in spring; tends to occur in masses (Ciba-Geigy 1968-). Considerable variability in progeny enhances survival of this species (Payne 1970).

Fire response: ? Resprouted — one plant flowering within 13 weeks of high-intensity fire (1/1994) at Narrabeen (P. Kubiak pers. comm.)

Interaction with other organisms: Known to cause hay fever and severe allergic conjunctivitis in humans, potential to cause asthma (Bass & Wrigley 1984). Potential to cause asthma in humans (Bass 1987). Cattle eating it develop sore mouths (Hurst 1942).

Distribution

Status/origin: Naturalised exotic, native to N America.

Botanical subregions: NC CC; Qld, S.A.

Distribution Sydney area: Only Sydney record, Cremorne (1948).

Select locations: Cremorne (1948)

Habitat

Habitat: Roadsides, wasteland and cultivation.

Altitude: 0–50 m

Annual rainfall: > 1200 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Weed of wasteland and cultivated areas north of Sydney, no recent records for Sydney area.

Ambrosia psilostachya *

ASTERACEAE

Perennial Ragweed

Life history

Growth form: Erect, stout herb to 2 m high, with rhizomes to almost 1 m deep; leaves aromatic.

Vegetative spread: Spread by creeping rhizomes and through cultivation — stimulation of new growth from damaged plant and pieces of rhizome (Parsons 1973). Often forms extensive colonies.

Longevity: Indefinite.

Primary juvenile period:

Flowers: Cream or green, late spring–summer (Parsons 1973).

Fruit/seed: Nut-like involucre with short spines, achene retained inside, one per fruit.

Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed over long distance due to spines on fruit; seeds germinate in autumn, plants develop rapidly in winter and spring developing extensive perennial roots and rhizomes, flowers late spring, aerial growth dies off in summer, new growth from buds on rhizomes in autumn; seeds can survive in soil for several years (Parsons 1973).

Fire response: Probably resprouts.

Interaction with other organisms: Pollen causes hay fever and severe allergic conjunctivitis in humans (Bass & Wrigley 1984). Not grazed by stock (Parsons 1973).

Distribution

Status/origin: Naturalised exotic, native to America. First recorded in Australia at Tomingley in NSW, 1924 (Parsons 1973).

Botanical subregions: NC CC NT CT NWS CWS SWS NWP SWP; Qld, Vic.

Distribution Sydney area: Mainly northern suburbs of Sydney.

Select locations: Lisarow, Mona Vale, Dee Why, Frenchs Forest, Willoughby, Mosman (1934), Earlwood, Orange.

Habitat

Habitat: Roadside, paddock.

Altitude: 0–1000 m

Annual rainfall: above 1000 mm

Typical local abundance: Uncommon–prolific.

Vegetation: Roadside and wasteland weeds.

Substrate: Sandy soil, damp sites, banks, possibly disturbed soil.

Exposure:

Conservation: Declared noxious weed in some shires.

Conservation

Ambrosia tenuifolia * (*Ambrosia confertifolia*)

ASTERACEAE

Lacy Ragweed

Life history

Growth form: Erect, aromatic herb to 75 cm high with long runner roots.

Vegetative spread: Spreads by long, underground, runner-like roots (Cunningham et al. 1981).

Longevity: Indefinite.

Primary juvenile period:

Flowers: Light green, December–April. Male flowerheads numerous, female heads single or few together (Cunningham et al. 1981).

Fruit/seed: Nut-like involucre with minute black achenes retained inside.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms: May cause hay fever and severe allergic conjunctivitis in humans (Bass & Wrigley 1984).

Distribution

Status/origin: Naturalised exotic, native to S America.

Botanical subregions: NC CC CT NWS CWS SWP NFWP; Vic., S.A., W.A.

Distribution Sydney area: Suburban areas.

Select locations: Wondabyne, Neutral Bay, Mascot, Ashfield (1932), Clyde, Granville, Albion Park, Moss Vale.

Habitat

Habitat: Railway lines, disturbed areas.

Altitude: 0–900 m

Annual rainfall: above 1000 mm

Typical local abundance: Common.

Vegetation: Weedy vegetation including, e.g. *Cortaderia selloana*, *Phragmites*.

Substrate: Sandy soil.

Exposure:

Conservation

Conservation: Declared noxious weed in some shires.

Ammobium alatum

ASTERACEAE

Life history

Growth form: Herb 60–100 cm high.

Vegetative spread:

Longevity: Perennial or facultative annual.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, November–March.

Fruit/seed: Achene 3–4 mm long, with pappus a membranous cup 0.5 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms: Suspected of causing string-halt in horses and death of stock (Hurst 1942).

Distribution

Status/origin: Native.

Botanical subregions: NC SC NT CT ST NWS CWS; Qld, *S.A.

Distribution Sydney area: Mainly cooler parts of the area.

Select locations: Kanimbla Valley, Mandurama, Orange, Bowral, Moss Vale, Mittagong (1938).

	Habitat
Habitat: Grassland and woodland, roadsides.	
Altitude: above 500 m	Annual rainfall: above 800 mm
Typical local abundance: Occasional-frequent.	
Vegetation: Grassland and woodland, roadsides,, e.g. with <i>Acacia mearnsii</i> .	
Substrate:	
Exposure: Full sun.	
	Conservation
Conservation:	

***Anthemis arvensis* ***

ASTERACEAE

Corn Chamomile

	Life history
Growth form: Herb to 60 cm high.	
Vegetative spread: No.	
Longevity: 1-2 years.	
Primary juvenile period:	
Flowers: White, disc yellow, December-February. Insect and self-pollinated (Ciba-Geigy 1968-).	
Fruit/seed: Achene 1.5-2.5 mm long, pappus an irregular rim, mature February.	
Dispersal, establishment & growth: Probably wind-dispersed (is ligule persistent for long enough to aid dispersal ?) Dispersed by wind, water, animals and humans (with white clover seeds); germinates in spring and autumn; moderate to vigorous user of nutrients and competitor for space (Ciba-Geigy 1968-).	
Fire response: Probably killed.	
Interaction with other organisms: Used in folk medicine for wound-healing and as a vermifuge (Ciba-Geigy 1968-).	

	Distribution
Status/origin: Naturalised exotic, native to S Europe. World-wide in temperate zones, companion since early Stone Age, now strongly regressing (Ciba-Geigy 1968-).	
Botanical subregions: NC NT CT; Vic., Tas., S.A.	
Distribution Sydney area: Taralga area.	
Select locations: Wombeyan Caves (1921), Richlands (1962).	

	Habitat
Habitat: Fields.	
Altitude: 800 m	Annual rainfall: 800 mm
Typical local abundance: Frequent.	
Vegetation: Grassy sites.	
Substrate: Nitrogenous soils, moist situations, indicator of acidity (Ciba-Geigy 1968-).	
Exposure:	
	Conservation
Conservation: Localised exotic, rarely recorded.	

***Anthemis cotula* ***

ASTERACEAE

Stinking Mayweed

	Life history
Growth form: Herb to 60 cm high with foetid scent.	
Vegetative spread: No.	
Longevity: 1 year.	
Primary juvenile period: Less than 1 year.	
Flowers: White, disc white-cream November-April.	
Fruit/seed: Achene 1.5 mm long, no pappus.	
Dispersal, establishment & growth: Dispersed by water, animals and humans (Ciba-Geigy 1968-).	
Fire response:	
Interaction with other organisms: 'rather a trouble on cultivated land but good food for	

horses and cattle when ripening' (James Walsh 1904 — Herbarium note). Thought to taint milk (Herbarium note).

Distribution

Status/origin: Naturalised exotic, native to Europe, Asia and Africa.

Botanical subregions: NC CC SC NT CT ST SWS NWP SWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Coast and Bathurst–Orange.

Select locations: Ourimbah, Turrumurra, Royal Botanic Gardens (1902), Flemington, Jambaroo, Jenolan Caves, Bathurst, Orange (1907).

Habitat

Habitat: Saleyards, paddocks.

Altitude: 0–1000 m **Annual rainfall:** above 1000 mm

Typical local abundance: Occasional–frequent.

Vegetation: Grasslands, cultivated land.

Substrate: Agricultural soils. Nitrogenous soil, clay indicator (Ciba-Geigy 1968–).

Exposure:

Conservation

Conservation: Weed of cultivated areas.

Arctium lappa *

ASTERACEAE

Greater Burdock

Life history

Growth form: Herb 1–1.5 m high.

Vegetative spread:

Longevity: 2 years.

Primary juvenile period:

Flowers: Purplish-red, summer–autumn.

Fruit/seed: Achene 6–7 mm long, with pappus 1–3.5 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: CT; Qld, Vic., N.Z.

Distribution Sydney area: Carcoar.

Select locations: 3 miles from Orange (1968) (only record).

Habitat

Habitat: Roadside.

Altitude: 700 m **Annual rainfall:** 700 mm

Typical local abundance:

Vegetation: Roadside vegetation.

Substrate: Shaley soil.

Exposure:

Conservation

Conservation: Only record indicates 'isolated infestation of a few square yards'.

Arctium minus *

ASTERACEAE

Common Burdock

Life history

Growth form: Herb 0.5–1.5 m high.

Vegetative spread:

Longevity: 2 years.

Primary juvenile period:

Flowers: Pink or purplish, summer–autumn.

Fruit/seed: Achene 5–7 mm long, with pappus 1–3.5 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

		Distribution
Status/origin: Naturalised exotic, native to Europe.		
Botanical subregions: NC CT NWP SWP; Tas.		
Distribution Sydney area: Orange area (Harden 1992).		
Select locations: No specimens for Sydney area.		
		Habitat
Habitat: Roadsides and disturbed sites.		
Altitude: 800 m	Annual rainfall: 1000 mm	
Typical local abundance:		
Vegetation:		
Substrate:		
Exposure:		
		Conservation
Conservation: Localised weed of disturbed sites.		

***Arctotheca calendula* *** (Cryptostemma calendula)

ASTERACEAE

Cape Weed, Cape Dandelion

Life history

Growth form: Herb to 30 cm high.
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Pale yellow, greenish or purple, September–November.
Fruit/seed: Achene 2 mm long with pappus of short scales.
Dispersal, establishment & growth: Diaspore: fruit. Wind-dispersed (Carr et al. 1992).
Fire response:
Interaction with other organisms: Known to cause allergy in humans where density is high (Bass 1987). Foodplant of butterfly caterpillar *Vanessa kershawi* (Coupar & Coupar 1992). Seeds eaten by Brown Songlark *Cinchorhamphus cruralis* (Barker & Vestjens 1989, 1990). Flowers eaten by Galah *Cacatua roseicapilla*, roots eaten by Sulphur-crested Cockatoo *Cacatua galerita*; flowers, seed, leaf midrib eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).

Distribution

Status/origin: Naturalised exotic, native to S Africa.
Botanical subregions: NC CC SC CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.
Distribution Sydney area: Coast, western Blue Mountains, Southern Highlands (P. Kodela pers. comm.).
Select locations: Gosford, Cheltenham, Brighton-le-sands, Cooks River (1912), Coogee, Cabramatta, Casula, Jenolan Caves (1899), Orange, Robertson (P. Kodela pers. comm.).

Habitat

Habitat: Lawns, pastures and cultivated areas.
Altitude: 0–1000 m **Annual rainfall:** above 800 mm
Typical local abundance: Frequent.
Vegetation: Pasture, lawn, edges of bushland.
Substrate: Beach sand, roadside gravel. Recorded on saline sites in western NSW (Semple 1993).
Exposure: Exposed, full sun.
Conservation
Conservation: Unlikely to invade bushland.

***Arctotheca populifolia* *** (*Arctotheca nivea*)

ASTERACEAE

Beach Daisy

Life history

Growth form: Semi-succulent herb to 30 cm high, with spreading growth.
Vegetative spread:
Longevity: Perennial.

Primary juvenile period:**Flowers:** Yellow, most of the year.**Fruit/seed:** Achene 5 mm long, covered with greyish wool, pappus of minute scales.**Dispersal, establishment & growth:** Diaspore: fruit, blown across ground or floats on water (buoyant for a few days). Possibly wind-dispersed (Carr et al. 1992). Seeds not dormant, high germination rate when fresh (and easily propagated (Heyligers 1983)).

Primary coloniser species of upper beach and mobile dunes. Drought-tolerant.

Fire response:**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to S Africa, first collected in W.A., 1930.**Botanical subregions:** NC CC SC; Vic., S.A., W.A.**Distribution Sydney area:** Coastline, first reported near Newcastle in 1930s (Nelson Bay 1937) and spread south to Brou Lake by 1981 (Heyligers 1983).**Select locations:** The Entrance (1946), Marley Beach (1971).**Habitat****Habitat:** Unstable littoral habitats, sandy hollows between dunes.**Altitude:** 0–20 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Occasional.**Vegetation:** Pioneer of beach sand on front dunes with *Spinifex sericeus*.**Substrate:** Beach sand dunes, calcareous and siliceous sand, infertile.**Exposure:** Exposed to salt spray, full sun, tolerant of sand blast.**Conservation****Conservation:** Suggested for beach stabilisation by Heyligers (1983) as it does not show any tendency to spread beyond the habitats to which it is confined in Africa (i.e. upper beach and mobile dunes) or compete with young native shrubs on the dunes.***Arctotis stoechadifolia* *****ASTERACEAE**

White Arctotis

Life history**Growth form:** Spreading herb to 35 cm high.**Vegetative spread:** Forms mats.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** Ray florets white above, mauve below, with a dark band at the base, disc purple-black, August–October.**Fruit/seed:** Achene 3–4 mm long, with pappus of scales 3–4 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to S Africa.**Botanical subregions:** NC CC CWS; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:** Northern Illawarra coast.**Select locations:** Thirroul (1946), Austinmer (1966).**Habitat****Habitat:** Weed of roadsides, beach margins.**Altitude:** 0–50 m**Annual rainfall:** above 1400 mm**Typical local abundance:** Isolated clumps.**Vegetation:** Beach margins.**Substrate:** Sandy soils, infertile.**Exposure:****Conservation****Conservation:** Garden escape unlikely to be spreading generally, though possibly spreading locally.

Arrhenechthites mixta

ASTERACEAE

Purple Fireweed

Life history**Growth form:** Herb to 90 cm high.**Vegetative spread:** No.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** White, December–March.**Fruit/seed:** Achene 5–7 mm long with pappus of white bristles 10–15 mm long, mature December–March.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC NT CT ST; Vic.**Distribution Sydney area:** Blue Mountains.**Select locations:** Clarence, Blackheath, Mt Victoria, Mt Wilson, Jenolan Caves, Hilltop, Wingello.**Habitat****Habitat:** Mostly in gullies.**Altitude:** 700–1200 m**Annual rainfall:** above 900 mm**Typical local abundance:** Occasional.**Vegetation:** Eucalypt woodland, ground stratum.**Substrate:** Sandstone–shale, infertile soil. Watertable mostly low, moisture supply intermittent, fresh.**Exposure:** Sheltered.**Conservation****Conservation:** Conservation status unknown.***Artemisia verlotiorum* ***

ASTERACEAE

Chinese Wormwood, Mugwort

Life history**Growth form:** Herb to 1 m, dying back to rootstock annually.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** February–March. Wind and self-pollinated (Ciba-Geigy 1968–).**Fruit/seed:** Achene, 1–1.5 mm long, no pappus, mature May.**Dispersal, establishment & growth:** Diaspore: seed. Water and wind-dispersed (Carr et al. 1992). Germinates in light; moderate–vigorous competitor for space and user of nutrients (Ciba-Geigy 1968–).**Fire response:****Interaction with other organisms:** Formerly used as a medicine, condiment, and for rites; unpleasant scent deters domestic animals; pollen causes hay-fever (Ciba-Geigy 1968–).**Distribution****Status/origin:** Naturalised exotic, native of SW China.**Botanical subregions:** NC CC SC NT CT ST CWS SWS SWP; Qld, Vic.**Distribution Sydney area:** Coast and upper Blue Mountains.**Select locations:** Manly, Vacluse, Dundas (1911), Beecroft, Katoomba, Lithgow, Wallerawang (1937), Moss Vale.**Habitat****Habitat:** Disturbed areas, often in moist sites.**Altitude:** 0–1100 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Frequent.**Vegetation:** Mid stratum.

Substrate: Shale and sandstone soils, fertile–infertile.

Exposure:

Conservation

Conservation: Naturalised exotic, apparently posing little problem.

Aster novi-belgii *

ASTERACEAE

Michaelmas Daisy

Life history

Growth form: Herb 0.2–1.4 m high, with long rhizomes.

Vegetative spread: Spreads by creeping root system.

Longevity: Indefinite.

Primary juvenile period:

Flowers: Purplish-blue, January–March.

Fruit/seed: Achene with pappus of bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to N America, garden escape.

Botanical subregions: CC CT.

Distribution Sydney area: Sydney suburbs and upper Blue Mountains.

Select locations: Northbridge (1965), Katoomba (1979), Portland (1982).

Habitat

Habitat: Moist swamps, gullies and on roadsides.

Altitude: 0–1000 m **Annual rainfall:** above 1000 mm

Typical local abundance: Occasional.

Vegetation:

Substrate: Sandy soils from sandstone, infertile, moist sites.

Exposure:

Conservation

Conservation: Occasional garden escape, naturalised near habitation.

Aster subulatus *

ASTERACEAE

Wild Aster, Bushy Starwort

Life history

Growth form: Herb 0.3–1.8 m high.

Vegetative spread: No.

Longevity: Annual, biennial or short-lived perennial.

Primary juvenile period: 1 year.

Flowers: White, pink or blue, at any time throughout the year.

Fruit/seed: Achene, 1.5–2 mm long, with pappus of bristles.

Dispersal, establishment & growth: Diaspore: fruit; water, wind, and possibly animal-dispersed (Carr et al. 1992).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to N America.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; LHI, Qld, Vic., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Dural, Epping, Sandringham (1902), Kurnell, Milperra, Richmond, Camden, Warrimoo, Wolgan Valley, Kowmung River, Bowral.

Habitat

Habitat: Riverbanks, swamp edges and roadside drains.

Altitude: 0–800 m **Annual rainfall:** above 700 mm

Typical local abundance: Occasional–frequent.

Vegetation: Swamp edges,, e.g. with *Ludwigia peploides*, *Paspalum distichum*.

Substrate: Seasonally wet, poorly drained or damp areas on sand, sandstone, shale and alluvium. Recorded on saline sites in western NSW (Semple 1993).

Exposure: Full sun.

Conservation

Conservation: Minor weed though may be important in wetland sites.

Baccharis halimifolia *

ASTERACEAE

Groundsel Bush

Life history

Growth form: Shrub 1–6 m high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellowish, December–May.

Fruit/seed: Achene 1–1.7 mm long with pappus of numerous hair-like bristles.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response:

Interaction with other organisms: Regarded as poisonous to sheep, suspected of poisoning other stock (Hurst 1942).

Distribution

Status/origin: Naturalised exotic, native to eastern N America.

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Illawarra coast.

Select locations: Wollongong (1982), Shellharbour (1984).

Habitat

Habitat: Near the sea, also in swampy areas, low-lying pasture and disturbed sites.

Altitude: 0–50 m **Annual rainfall:** above 1200 mm

Typical local abundance: Occasional.

Vegetation: Often behind mangroves, or low-lying pasture.

Substrate: Sands, infertile.

Exposure: ? full sun.

Conservation

Conservation: Recently recorded for Sydney area, declared noxious weed in some shires.

Bidens pilosa *

ASTERACEAE

Cobblers Pegs, Pitch-forks

Life history

Growth form: Woody herb to 1.5 m high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: 18 weeks (P. Kubiak pers. comm.).

Flowers: Usually white, throughout the year but mainly March–May.

Fruit/seed: Achene with pappus of barbed awns, mature at any time but mainly March–May. Single plant can produce 3000–6000 seeds, 80 % still capable of germination after 3–5 years stored in soil (M. Clarke pers. comm.). An indeterminate number capable of germination after more than 30 years (R. Buchanan pers. comm.).

Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed (e.g. on human clothing).

Fire response: Probably killed, vigorous recruitment from seed after high-intensity fire (1/1994) at Narrabeen; most likely from soil-stored seed (M. Clarke pers. comm.). Mature fruit within 18 weeks of high-intensity fire (1/1994) at Narrabeen and Lane Cove (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to S America. Used medicinally, in Asia, New Guinea, and Polynesia (Cambie & Ash 1994).

Botanical subregions: NC CC SC NT ST NWS CWS NWP SWP; LHI, Qld, Vic., N.T., S.A., W.A.

Distribution Sydney area: Mainly coastal.

Select locations: Gosford, Palm Beach, Wahroonga, Belrose & Cherrybrook (P. Kodela pers. comm.), Port Jackson (1886), La Perouse, Cabarita, Wollongong, Albion Park, Grose Vale, Ingleburn, Razorback.

Habitat

Habitat: Disturbed sites, roadsides.

Altitude: 0–200 m **Annual rainfall:** above 700 mm

Typical local abundance: Frequent.

Vegetation: With other weeds of frequently disturbed sites.

Substrate: Clay soils from Wianamatta Shale, sandstones, alluvium, fill etc., any substrate (R. Buchanan pers. comm.), no special requirements for nutrient, moisture etc. (M. Clarke pers. comm.).

Exposure: Light shade–full sun.

Conservation

Conservation: Common weed, in recently or frequently disturbed sites.

Bidens subalternans *

ASTERACEAE

Greater Beggar's Ticks

Life history

Growth form: Woody herb to 1.6 m high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, March–April.

Fruit/seed: Barbed achene, with pappus of barbed awns, mature February–June.

Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed, e.g. on clothing.

Fire response: Probably killed; flowering within 12 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.)

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to S America.

Botanical subregions: NC CC NWS CWS NWP SWP; Qld.

Distribution Sydney area: Mainly Western Sydney.

Select locations: Lindfield (1951), Parramatta, Cattai Creek, Emu Plains, Casula, Camden, Menangle, Albion Park.

Habitat

Habitat: Disturbed sites — along railway lines, wasteland, roadsides.

Altitude: 0–200 m **Annual rainfall:** 700–1000 mm

Typical local abundance: Common.

Vegetation: With other weeds, e.g. *Bidens pilosa*, *Sida rhombifolia*.

Substrate: Sandy soils, consolidated sand dune, infertile.

Exposure:

Conservation

Conservation:

Bidens tripartita *

ASTERACEAE

Burr Marigold

Life history

Growth form: Woody herb to 1 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Yellow, March–May.

Fruit/seed: Barbed achene, 4–8 mm long, with pappus of barbed awns 2–4 mm long, mature March–May.

Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed.

Fire response: Probably killed; flowering and fruiting within 15 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: NC CC SC NT CT ST; Vic.

Distribution Sydney area: Mainly coastal.

Select locations: Centennial Park, Macquarie Pass, Bellawongarah, (1904), Cambewarra, Bowral, Wingecarribee Swamp (P. Kodela pers. comm.).

Habitat

Habitat: Swampy ground, damp pasture (P. Kodela pers. comm.).

Altitude: 0–700 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Margin of swamps.

Substrate: Moist sites, poorly-drained.

Exposure:

Conservation

Conservation:

Brachycome aculeata

ASTERACEAE

Hill Daisy

Life history

Growth form: Herb to 60 cm high. Populations vary in shape of leaves and branching of inflorescence.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: White–mauve, September–May.

Fruit/seed: Achene, flattened, 3–4 mm long, with pappus a small tuft of bristles 0.3 mm long.

Dispersal, establishment & growth: Diaspore: fruit.

Fire response:

Interaction with other organisms: Palatable to rabbits (Leigh et al. 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS NWP; Qld, Vic., Tas., S.A.

Distribution Sydney area: Mostly Bathurst to Taralga, early records from Sydney area.

Select locations: Palm Beach (1916), Parramatta (von Mueller), Richmond (1913), Richlands, Black Range, Jenolan Caves, Jenolan SF, Bathurst, Wombeyan Caves, Mittagong, Barbers Creek (1899). (Some material on loan.)

Habitat

Habitat: Roadside.

Altitude: 0–1000 m

Annual rainfall: above 600 mm

Typical local abundance:

Vegetation: Grassland, ground stratum.

Substrate: Well drained to dry sites.

Exposure:

Conservation

Conservation: Conservation status unknown.

Brachycome angustifolia var. *angustifolia*

ASTERACEAE

Life history

Growth form: Stoloniferous, ascending herb to 35 cm high; leaves entire.**Vegetative spread:** Stoloniferous.**Longevity:** Indefinite, stolons up to 10 cm long forming new plants; vegetative production of new plants may allow continued replacement as old plants die.**Primary juvenile period:****Flowers:** Pink, blue or mauve, November–March.**Fruit/seed:** Achene, flattened 2 mm long, pappus 0.4 mm long.**Dispersal, establishment & growth:** Diaspore: fruit.**Fire response:** Possibly resprouts from stolons. Flowering within 11 weeks and fruiting within 16 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).**Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** CC SC NT CT ST NWS; Vic., Tas., S.A.**Distribution Sydney area:** Coast and western Sydney, Blue Mountains.**Select locations:** Warnervale, Gordon, Ermington, Duck River, Cronulla, Appin, Douglas Park, Llandillo, Lidsdale, Katoomba, Kowmung River, Bowral. (Some material on loan.)

Habitat

Habitat:**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Occasional.**Vegetation:** Moist–dry eucalypt open-forest. Ground stratum.**Substrate:** Clay soils from shales, also sandstone. Fertile soil. Watertable mostly low, moisture supply intermittent, fresh.**Exposure:** Sheltered.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.*Brachycome angustifolia* var. *heterophylla*

ASTERACEAE

Life history

Growth form: Stoloniferous, ascending herb to 35 cm high, leaves pinnatisect to deeply toothed.**Vegetative spread:** Stoloniferous.**Longevity:** Indefinite.**Primary juvenile period:****Flowers:** Pink, blue or mauve, November–March.**Fruit/seed:** Achene, flattened, 2 mm long, pappus of bristles, 0.4 mm long.**Dispersal, establishment & growth:** Diaspore: fruit.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS; Vic.**Distribution Sydney area:** Mainly western Blue Mountains and southern Highlands.**Select locations:** North of Windsor, Toongabbie (1859), El Dorado, Mt Costigan, Abercrombie Caves, Stingray Swamp, Wingecarribee Swamp, Joadja. (Some material on loan.)

Habitat

Habitat: Eucalypt open-forest.**Altitude:** 0–1000 m**Annual rainfall:** above 800 mm**Typical local abundance:****Vegetation:** Eucalypt open-forest.**Substrate:** Possibly associated with swampy soils.**Exposure:**

Conservation

Conservation: Conservation status unknown.

Brachycome decipiens

ASTERACEAE

Field Daisy

Life history

Growth form: Herb to 20 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Pale blue, September–November.**Fruit/seed:** Achene 3 mm long, with minute pappus.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:** Palatable to rabbits (Leigh et al. 1987).

Distribution

Status/origin: Native.**Botanical subregions:** CT ST; Vic., Tas.**Distribution Sydney area:** Chiefly south from Braidwood area (Harden 1992).**Select locations:** Jenolan Caves (1899). (Some material on loan.)

Habitat

Habitat:**Altitude:** 800 m**Annual rainfall:** 1000 mm**Typical local abundance:****Vegetation:** Subalpine and montane woodland and swamps (Harden 1992).**Substrate:****Exposure:**

Conservation

Conservation: Conservation status unknown.***Brachycome diversifolia* var. *dissecta***

ASTERACEAE

Large-headed Daisy

Life history

Growth form: Herb to 45 cm high; leaves 2-pinnatisect.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** White–mauve, June–December.**Fruit/seed:** Achene 2–3 mm long, with pappus of hairs 0.5 mm long, mature February.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NT CT NWS NWP; Qld.**Distribution Sydney area:** Western Blue Mountains.**Select locations:** Rylstone (1938), Katoomba (1932). (Some material on loan.)

Habitat

Habitat: Rocky outcrops.**Altitude:** 700–1000 m**Annual rainfall:** above 900 mm**Typical local abundance:****Vegetation:** Ground stratum.**Substrate:** Soil pockets in depressions of rocky outcrops.**Exposure:**

Conservation

Conservation: Southern limit Katoomba; possibly rare. Conservation status unknown.

Brachycome diversifolia* var. *diversifolia

ASTERACEAE

Large-headed Daisy

Life history**Growth form:** Herb to 45 cm high; leaves 1-pinnatisect.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** White-mauve, November–April.**Fruit/seed:** Achene 2–3 mm long, with pappus of hairs 0.5 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NT CT ST SWS; Tas., S.A.**Distribution Sydney area:** Western Blue Mountains.**Select locations:** Capertee, Zig Zag, Blackheath, Mt Victoria, Sunny Corner. (Some material on loan.)**Habitat****Habitat:** Damp rocky areas.**Altitude:** 700–1000 m**Annual rainfall:** above 900 mm**Typical local abundance:****Vegetation:** Ground stratum.**Substrate:** Sandy soil — damp rocky areas.**Exposure:****Conservation****Conservation:** Conservation status unknown.***Brachycome formosa***

ASTERACEAE

Pilliga Posy

Life history**Growth form:** Rhizomatous herb to 15 cm high. Chromosome number $n = 9$ (Short 1988).**Vegetative spread:** Possibly.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** Pink, September–November.**Fruit/seed:** Achene 2–3 mm long, wing narrow, with slightly inflated, pappus 0.2 mm long.

Observations of low seed set in cultivated specimens suggests self-incompatibility (Short 1988).

Dispersal, establishment & growth: Diaspore: fruit.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CT NWS CWS.**Distribution Sydney area:** Bathurst area.**Select locations:** Bathurst–Grattai Rd (1953), high mountains near Mudgee (1872) (Short 1988). (Some material on loan.)**Habitat****Habitat:** In grass along roadside, on sandstone ridges (Short 1988).**Altitude:****Annual rainfall:****Typical local abundance:****Vegetation:** Dry eucalypt open-forest and woodland with sparse shrub understorey. Under *Angophora floribunda* (Short 1988).**Substrate:****Exposure:****Conservation****Conservation:** Rare, conservation status unknown.

Brachycome graminea

ASTERACEAE

Life history**Growth form:** Stoloniferous herb to 70 cm high.**Vegetative spread:** Stoloniferous.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** Blue-violet, December–February.**Fruit/seed:** Achene 2 mm long, no pappus.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC NT CT ST; Qld, Vic., Tas., S.A.**Distribution Sydney area:** Western Blue Mountains, also Razorback.**Select locations:** Razorback, Blackheath, Newnes Junction, Capertee, Gardiners Gap, Bathurst, Blayney. (Some material on loan.)**Habitat****Habitat:** Swampy ground.**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent.**Vegetation:** Eucalypt woodland, shrub swamps.**Substrate:** Swampy ground on shale and sandstone. Soil fertile–infertile, watertable mostly high, non-saline.**Exposure:** No shade.**Conservation****Conservation:** Conservation status unknown.***Brachycome heterodonta* var. *heterodonta***

ASTERACEAE

Life history**Growth form:** Erect herb to 50 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** White or bluish, September–December.**Fruit/seed:** Achene, flattened 3–4 mm long, pappus 0.7 mm long.**Dispersal, establishment & growth:** Diaspore: fruit. Short distance wind-dispersed, probably also dispersed by water.**Fire response:** Probably reshoots from rhizome.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., S.A.**Distribution Sydney area:****Select locations:** Bathurst to Sofala (1910). (Some material on loan.)**Habitat****Habitat:****Altitude:****Annual rainfall:****Typical local abundance:****Vegetation:** Ground stratum.**Substrate:****Exposure:****Conservation****Conservation:** Conservation status unknown.

Brachycome microcarpa

ASTERACEAE

Life history**Growth form:** Herb to 58 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** White or bluish, September–February.**Fruit/seed:** Achene 1–2 mm long with glandular hairs, pappus of white bristles 0.1 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

Distribution**Status/origin:** Native.**Botanical subregions:** NC NT CT NWS; Qld.**Distribution Sydney area:****Select locations:** Littleton (1893), Abercrombie Caves (1951). (Specimens on loan.)

Habitat**Habitat:****Altitude:** 600–1000 m**Annual rainfall:** 900 mm**Typical local abundance:****Vegetation:** Open-forest.**Substrate:** Well-drained sites.**Exposure:**

Conservation**Conservation:** Conservation status unknown.***Brachycome multifida* var. *dilatata***

ASTERACEAE

Cut-leaved Daisy

Life history**Growth form:** Herb to 45 cm high (leaf segments broad-linear).**Vegetative spread:****Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Mauve, pink or white, March–October.**Fruit/seed:** Achene 2 mm long, pappus of spreading bristles 0.1 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

Distribution**Status/origin:** Native.**Botanical subregions:** NC CC; Vic.**Distribution Sydney area:** Wisemans Ferry.**Select locations:** Wisemans Ferry (1908). (Some material on loan.)

Habitat**Habitat:** Sclerophyll forest.**Altitude:** 0–200 m**Annual rainfall:** 800 mm**Typical local abundance:****Vegetation:** Sclerophyll forest. Ground stratum.**Substrate:****Exposure:**

Conservation**Conservation:** Conservation status unknown.

Brachycome multifida* var. *multifida

ASTERACEAE

Cut-leaved Daisy

Life history

Growth form: Herb to 45 cm high.

Vegetative spread: Sprawling stems capable of layering (L.McD.)

Longevity: Annual.

Primary juvenile period: Less than 1 year.

Flowers: Mauve, pink or white, September–June.

Fruit/seed: Achene 2 mm long, with pappus of spreading bristles 0.1 mm long.

Dispersal, establishment & growth: [Easily grown from cuttings (L.McD.)]

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT CT NWS CWS NWP SWP SFWP; Qld, Vic.

Distribution Sydney area: Western Sydney, Minnamurra, Bathurst.

Select locations: Maroota, Windsor, Minnamurra Falls, Bathurst, Mt Wiagdon. (Some material on loan.)

Habitat

Habitat:

Altitude: 0–1000 m **Annual rainfall:** above 700 mm

Typical local abundance: Frequent.

Vegetation: Sclerophyll forest or grassland (e.g. with *Eucalyptus piperita* at Maroota).

Ground stratum.

Substrate: Yellow clay, infertile soil.

Exposure:

Conservation

Conservation: Conservation status unknown.

Brachycome procumbens

ASTERACEAE

Life history

Growth form: Stoloniferous, ascending herb to 35 cm high.

Vegetative spread: Stoloniferous.

Longevity: Perennial.

Primary juvenile period:

Flowers: September–March.

Fruit/seed: Achene 2.5 mm long, pappus 0.2 mm long.

Dispersal, establishment & growth: Diaspore: fruit.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC NT CT NWS CWS; Qld.

Distribution Sydney area: Ben Bullen SF.

Select locations: Ben Bullen SF. (Some material on loan.)

Habitat

Habitat:

Altitude: 800 m **Annual rainfall:** 800 mm

Typical local abundance:

Vegetation: Open-forest, e.g. with *Eucalyptus dives* and grassy understorey.

Substrate: Clay loam. Infertile soil. Watertable mostly low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Conservation status unknown.

Brachycome ptychocarpa

ASTERACEAE

Life history

Growth form: Glabrous herb 5–10 cm high. Some plants from the CT differ in being stoloniferous perennial herbs and could represent a new, closely related taxon.

Vegetative spread: No, (some plants from CT are stoloniferous).

Longevity: Annual, (some plants from CT are perennial).

Primary juvenile period:

Flowers: Pink, October–April.

Fruit/seed: Achene 2 mm long, with broad wings and pappus of bristles 0.2 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NT CT ST CWS; Vic.

Distribution Sydney area: Bathurst–Orange

Select locations: Kandos, Wattle Flat, Meadow Flat, Glenroy, Springside, Mt Canobolas, Carcoar. (Some material on loan.)

Habitat

Habitat:

Altitude: 700–1400 m

Annual rainfall: 600–900 mm

Typical local abundance: Occasional.

Vegetation: Woodland, e.g. with *Eucalyptus pulverulenta* ground stratum.

Substrate: Moist ground, granite. Infertile soil.

Exposure:

Conservation

Conservation: Conservation status unknown.

Brachycome rigidula

ASTERACEAE

Life history

Growth form: Herb to 36 cm high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Blue, October–February.

Fruit/seed: Achene 2–3 mm long, winged; pappus of hairs 0.2 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms: Palatable to rabbits (Leigh et al. 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC SC NT CT ST; Qld, Vic., Tas.

Distribution Sydney area: Western fringe of the Blue Mountains.

Select locations: Mt Walker. (Some material on loan.)

Habitat

Habitat:

Altitude:

Annual rainfall:

Typical local abundance:

Vegetation: Woodland with *Eucalyptus rossii*, *E. mannifera*, *E. dives*.

Substrate: Well-drained sites, among rocks — quartzites, siltstones.

Exposure:

Conservation

Conservation: Conservation status unknown.

Brachycome scapigera

ASTERACEAE

Life history**Growth form:** Erect, glabrous herb to 40 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** White or mauve, November–March.**Fruit/seed:** Achene 2–3 mm long, flattened, pappus minute (0.1 mm long).**Dispersal, establishment & growth:** Diaspore: fruit.**Fire response:****Interaction with other organisms:** Palatable to rabbits (Leigh et al. 1987).**Distribution****Status/origin:** Native.**Botanical subregions:** SC NT CT ST NWS CWS; Qld, Vic.**Distribution Sydney area:** Southern highlands.**Select locations:** Jenolan Caves (1899), Wingello (1899), Wingecarribee Swamp (1969).

(Some material on loan.)

Habitat**Habitat:** Moist sites.**Altitude:** 600–1000 m**Annual rainfall:** 800–1000 mm**Typical local abundance:****Vegetation:** Ground stratum, sclerophyll forest subalpine communities

(Burbidge & Gray 1976).

Substrate: Moist sites, probably low nutrient sandy sites.**Exposure:****Conservation****Conservation:** Conservation status unknown.***Brachycome spathulata* (Brachycome scapiformis)**

ASTERACEAE

Life history**Growth form:** Erect, tufted herb to 60 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Pale blue–mauve, rarely white, October.**Fruit/seed:** Achene 1–3 mm long, pappus has membranous wings and a tuft of bristles 0.2–0.8 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:** Palatable to rabbits (Leigh et al. 1987).**Distribution****Status/origin:** Native.**Botanical subregions:** SC NT ST CT CWS SWS; Vic., Tas.**Distribution Sydney area:** Bathurst–Orange, Shoalhaven Heads.**Select locations:** Hartley Vale, Mullions Range, Gurnang SF, Wombeyan Caves, Berrima, Shoalhaven Heads. (Some material on loan.)**Habitat****Habitat:** Open areas.**Altitude:** 0–1000 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Frequent.**Vegetation:** Eucalypt woodland, e.g. *Eucalyptus macrorhyncha*. Ground stratum.**Substrate:** Heavy red and brown clay soils; quartzitic soils.**Exposure:****Conservation****Conservation:** Conservation status unknown.

Brachycome stuartii

ASTERACEAE

Life history

Growth form: Erect, tufted herb to 25 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** White, mauve or pale blue, April–November.**Fruit/seed:** Achene 1–2 mm long with pappus of bristles 0.1 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC NT CT NWS; Qld.**Distribution Sydney area:** North from Bathurst.**Select locations:** Trunkey (1918). (Some specimens on loan.)

Habitat

Habitat: Swampy ground.**Altitude:****Annual rainfall:****Typical local abundance:** Frequent.**Vegetation:****Substrate:****Exposure:**

Conservation

Conservation: Conservation status unknown.***Bracteantha bracteata*** (*Helichrysum bracteatum*)

ASTERACEAE

Golden Everlasting

Life history

Growth form: Herb to 1 m high with shallow root system. A variable complex that requires investigation (Harden 1992).**Vegetative spread:** No.**Longevity:** Short. Usually annual.**Primary juvenile period:****Flowers:** Yellow or straw-coloured flowers, June–March, peak January.**Fruit/seed:** Achene 1 mm long, with pappus of bristles 4 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed. Seedling recruitment fire or disturbance related.**Fire response:** Probably killed.**Interaction with other organisms:** Host to Root Knot Nematode *Meloidogyne incognita*, causes irregular swellings and galls on roots resulting in stunting and/or death of plant (Jones & Elliot 1986).

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.**Distribution Sydney area:** Coast, Upper Blue Mountains and Southern Highlands.**Select locations:** Ingleburn, Waterfall, Mt Keira, Berry, Mt Tomah, Rylstone, Jensens Swamp, Wombeyan Caves, Wingecarribee Swamp (P. Kodala pers. comm.), The Gib, Wingello.

Habitat

Habitat: Various habitats, forest to swamplands or disturbed sites, e.g. roadsides.**Altitude:** 0–1200 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Open-forest, e.g. with *Eucalyptus pilularis* or shrubby swampland with *Restio australis*, *Empodisma minus*.**Substrate:** Soils from basalt, shale, limestone, rarely sandstone, fertile–very fertile. Also in

peat (P. Kodela pers. comm.). Watertable mostly high, moisture supply intermittent, fresh.

Exposure: Sheltered situations; light–no shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991). Conservation status elsewhere unknown.

Bracteantha viscosa (*Helichrysum viscosum*)

ASTERACEAE

Sticky Everlasting

Life history

Growth form: Herb to 1 m

Vegetative spread:

Longevity: Usually annual.

Primary juvenile period: Less than 1 year.

Flowers: November–May, peak November.

Fruit/seed: Achene 2 mm long, with pappus of golden bristles; mature February (limited data).

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic ??

Distribution Sydney area: Mainly western Blue Mountains.

Select locations: Liverpool, Lithgow, Bathurst–Sofala, Mullion Range, Hill Top, The Gib.

Habitat

Habitat: Rock crevices on dry slopes.

Altitude: 0–1200 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent.

Vegetation: Woodland, e.g. with *Stypandra glauca*.

Substrate: Rock crevices on dry slopes, volcanic rocks. Soil fertile. Watertable permanently low, moisture supply intermittent, fresh.

Exposure: Exposed situations.

Conservation

Conservation: Possibly rare, conservation status unknown.

Calendula arvensis*

ASTERACEAE

Field Marigold

Life history

Growth form: Herb 5–40 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Orange-yellow, November.

Fruit/seed: Achene 1–1.5 mm long, with spines to 5 mm long, no pappus, mature November–January.

Dispersal, establishment & growth: Diaspore: fruit, probably animal-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Mediterranean region.

Botanical subregions: CC NT CT CWS NWP SWP SFWP; Qld, Vic., Tas., S.A.

Distribution Sydney area: Western Sydney, Orange.

Select locations: Smithfield (1919), Seven Hills (1920), South Orange (1975).

Habitat

Habitat: Weed of orchards.

Altitude: 0–1000 m

Annual rainfall: 800–1000 mm

Typical local abundance:

Vegetation: Orchards.

Substrate:

Exposure:

Conservation: Uncommon weed.

Conservation

Calendula officinalis *

ASTERACEAE

Life history

Growth form: Herb 15–50 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, May–Dec.

Fruit/seed: Achene 2.5 mm long, no pappus (150 seeds per gram).

Dispersal, establishment & growth: Diaspore: achene, no dormancy.

Fire response: Probably killed.

Interaction with other organisms: Susceptible to Calendula Rust (Rowell 1970).

Distribution

Status/origin: Naturalised exotic, native to Mediterranean. Introduced as a garden plant.

Botanical subregions: CT ?SC NWS; Tas., S.A.

Distribution Sydney area: Orange.

Select locations: Orange (1936, 1983).

Habitat

Habitat: Roadside, orchards.

Altitude: 600–1000 m

Annual rainfall: 1000 mm

Typical local abundance: Frequent.

Vegetation: Roadside, orchards.

Substrate:

Exposure:

Conservation

Conservation: Garden escapes in Orange area; possibly naturalised in Nowra area.

Calendula palaestina *

ASTERACEAE

Palestine Marigold

Life history

Growth form: Herb 20–40 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Light yellow, spring.

Fruit/seed: Achene 2.5–4 mm long, no pappus.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Mediterranean region.

Botanical subregions: CT SWP.

Distribution Sydney area: CT (Harden 1992).

Select locations: No herbarium records.

Habitat

Habitat: Moist sites.

Altitude:

Annual rainfall:

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Rarely naturalised (Harden 1992).

Calocephalus citreus

ASTERACEAE

Lemon Beauty-heads

Life history

Growth form: Herb, erect from tufted base, 15–60 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Bright golden yellow, late spring–autumn (Harden 1992).**Fruit/seed:** Achene 0.7–0.9 mm long, with pappus of bristles.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC NT CT ST CWS SWS SWP; Qld, Vic., Tas., S.A.**Distribution Sydney area:** Probably in western part of the area.**Select locations:** Specimens unavailable.

Habitat

Habitat:**Altitude:****Annual rainfall:****Typical local abundance:** Rarely abundant (Harden 1992).**Vegetation:** Grassland or woodland (Harden 1992).**Substrate:** Clay or loam soils (Harden 1992). Recorded on saline sites in western NSW (Semple 1993).**Exposure:**

Conservation

Conservation: Status unknown.

Calomeria amaranthoides (Humea elegans)

ASTERACEAE

Incense Plant

Life history

Growth form: Quick-growing herb to 2 m high, with woolly stem and sticky, aromatic leaves.**Vegetative spread:** No.**Longevity:** 2 years**Primary juvenile period:****Flowers:** December–April, insect-pollinated?**Fruit/seed:** Achene, no pappus, mature March–April.**Dispersal, establishment & growth:** Diaspore: fruit, ? limited local dispersal, water-dispersed? Growth rate quick. Coloniser.**Fire response:** Probably killed, recruitment from ? soil-stored seed, grows vigorously after fire.**Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC CT; Vic.**Distribution Sydney area:** Blue Mountains, Hawkesbury River (rare).**Select locations:** Rhodes (1888), Penshurst (1894), Loftus, Minto, Douglas Park, Mt Keira, Burragorang Valley, Berambing, Mt Tomah, Mt Wilson, Wingello.

Habitat

Habitat: River flats, creekbanks, gullies, roadsides.

Altitude: 0–800 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent–occasional.

Vegetation: Rainforest or margins, e.g. with *Doryphora–Ceratopetalum*. Moist eucalypt forest, e.g. with *Eucalyptus fastigata*, *E. blaxlandii*, *E. cypellocarpa*.

Substrate: Sandy alluvial soils, sandstone, shale and basalt, fertile–very fertile, well-drained.

Exposure: Light–mid shade

Conservation

Conservation: Probably poorly conserved. Vulnerable in Western Sydney (Benson & McDougall 1991). Status elsewhere unknown.

Calotis cuneifolia

ASTERACEAE

Purple Burr-daisy

Life history

Growth form: Erect, sometimes prostrate, herb to 60 cm high.

Vegetative spread: No.

Longevity: Perennial.

Primary juvenile period:

Flowers: White or lilac, August–May, peak September–October.

Fruit/seed: Achene, flattened, 1–2 mm long, surmounted by 2 erect barbed spines 1–4 mm long, forming a burr. Mature October–May.

Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed. In western NSW, growth commences from seed or recommences from old plants in autumn and provided soil moisture is available plants grow well into summer (Cunningham et al. 1981).

Fire response: Probably killed.

Interaction with other organisms: Grazed by stock (Cunningham et al. 1981).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., N.T., S.A.

Distribution Sydney area: Western Sydney, Blue Mountains.

Select locations: Hornsby, Rookwood, Chester Hill, Marsden Park, Berkshire Park, St Marys, Nortons Basin, Lapstone, Warrimoo, Blackheath, Clarence.

Habitat

Habitat: Woodland.

Altitude: 0–1300 m

Annual rainfall: 600–1200 mm

Typical local abundance: Occasional–frequent.

Vegetation: Eucalypt woodland with *Melaleuca nodosa* understory or *Melaleuca* scrub.

Substrate: Clay soils from Wianamatta Shale, also Tertiary alluvium and occasionally on sandstone, moderate fertility. Watertable mostly low.

Exposure:

Conservation

Conservation: Inadequate, most habitat is under threat.

Calotis dentex

ASTERACEAE

White Daisy Burr

Life history

Growth form: Hairy herb to 80 cm high.

Vegetative spread: No.

Longevity: Perennial.

Primary juvenile period:

Flowers: White, conspicuous, November–April.

Fruit/seed: Achene 2 mm long, with barbed awns 4–6 mm long, forming a burr. Matures December–April.

Dispersal, establishment & growth: Diaspore: fruit, probably animal-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT CT NWS; Qld.

Distribution Sydney area: Mainly along Nepean (sporadically from Bargo–Richmond) and Georges River (Glenfield, East Hills) with some outlying populations.

Select locations: Howes Valley, Richmond, Ingleburn, Homebush, Glenfield, Picton, Bargo, Yerranderie, Fitzroy Falls, Albion Park, Meryla.

Habitat

Habitat: Creek banks, lower hillslopes.

Altitude: 0–600 m

Annual rainfall: 600–1400 mm

Typical local abundance: Occasional–frequent.

Vegetation: Forests and grassy woodlands,, e.g. with dense *Bursaria* thicket.

Substrate: Loamy soils, moderate to high fertility alluvium or adjacent hill sides on sandstone and shale, possibly needs good soils for initial establishment and growth.

Exposure: Mid–light shade.

Conservation

Conservation: Inadequately conserved, now rare in Sydney area. Vulnerable in Western Sydney (Benson & McDougall 1991). Meryla — southern limit.

Calotis glandulosa

ASTERACEAE

Life history

Growth form: Herb to 30 cm high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: White–blue, December–February.

Fruit/seed: Achene 1–2 mm long, with barbed awns 1–5 mm long, forming burr.

Dispersal, establishment & growth: Diaspore: fruit, probably animal dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: SC CT ST CWS.

Distribution Sydney area: Only record is Duckmaloi (1935).

Select locations: Duckmaloi (1935).

Habitat

Habitat:

Altitude: 1100 m

Annual rainfall: 900 mm

Typical local abundance: Very rare.

Vegetation: Grasslands and open-forest.

Substrate:

Exposure:

Conservation

Conservation: Rare.

Calotis hispidula

ASTERACEAE

Bogan Flea

Life history

Growth form: Prostrate or ascending herb with small yellow flowers, to 25 cm high, sometimes forming a dense mat.

Vegetative spread: No.

Longevity: Annual.

Primary juvenile period:

Flowers: Yellow, August (October).

Fruit/seed: Achene 1–2 mm long, with barbed awns 1.5–2.5 mm long, forming burr. Mature August–October.

Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed (e.g. clothing, wool). In western NSW, a cool season annual, mainly growing on floodplains after floodwaters have receded, or following heavy winter rains (Cunningham et al. 1981).

Fire response:

Interaction with other organisms: Palatable to stock during early growth.

Distribution

Status/origin: Native.

Botanical subregions: NC CC NWS CWS SWS NWP SWP NFWP SFWP; mainland States.

Distribution Sydney area: Western Sydney.

Select locations: Cowan (1921), Parramatta (1887), Flemington, Richmond (1910), Blacktown (1910), Bringelly (1912).

Habitat

Habitat: Dry situations. Recorded beside railways, saleyards, in lawns.

Altitude: 0–200 m **Annual rainfall:** 600–1100 mm

Typical local abundance: Occasional.

Vegetation: Grasslands, open-forests, roadsides.

Substrate: Probably well drained clay soils. Recorded on saline sites in western NSW (Semple 1993).

Exposure:

Conservation

Conservation: A rare species, not conserved.

Calotis lappulacea

ASTERACEAE

Yellow Burr-daisy

Life history

Growth form: Much-branched, hairy herb to 50 cm high with yellow flowers.

Vegetative spread: No.

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, throughout the year.

Fruit/seed: Achene 1–1.5 mm long, with barbed awns forming burr with bristles, developed soon after flowering.

Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Southern Cumberland Plain and lower Blue Mountains.

Select locations: Howes Valley, Epping, Richmond, Bankstown, Glenfield, Bringelly, Camden, Lapstone, Silverdale, Jenolan River, Abercrombie Caves, Goodmans Ford.

Habitat

Habitat:

Altitude: 0–500 m **Annual rainfall:** above 600 mm

Typical local abundance: Occasional–frequent.

Vegetation: Grassy woodland, e.g. with *Eucalyptus moluccana*, *E. melliodora*, *E. albens*.

Substrate: Heavy clay soils from Wianamatta Shale or Devonian Lambie Group. Fertile soil. Watertable permanently low, moisture supply intermittent, fresh.

Exposure: No shade–light shade.

Conservation

Conservation: Inadequately conserved, becoming rare in Sydney area. Vulnerable in Western Sydney (Benson & McDougall 1991). 60 % (24/38) Herbarium specimens collected pre. 1960.

Calotis scabiosifolia* var. *integrifolia

ASTERACEAE

Rough Burr-daisy

Life history

Growth form: Hairy herb to 40 cm high.

Vegetative spread: Spreads by stolons.

Longevity: Indefinite.

Primary juvenile period:

Flowers: White-mauve, October-February.

Fruit/seed: Achene, flattened, 3-4 mm long with 5-6 rigid spines 1-4 mm long.

Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed. In western NSW plants dry off during summer, but may persist in favourable situations (Cunningham et al. 1891).

Fire response:

Interaction with other organisms: Grazed by stock.

Distribution

Status/origin: Native.

Botanical subregions: CT ST SWS SWP; Vic.

Distribution Sydney area: Bathurst-Orange, Wingello.

Select locations: Known only from old specimens, Wallerawang (1899), Wingello (1913), Orange (1907).

Habitat

Habitat:

Altitude: 600-1100 m

Annual rainfall: 900-1200 mm

Typical local abundance:

Vegetation: Open woodland and grassland.

Substrate: Probably clay soils.

Exposure:

Conservation

Conservation: Possibly locally extinct, only known from old records.

Calotis scapigera

ASTERACEAE

Tufted Burr-daisy

Life history

Growth form: Herb to 35 cm high.

Vegetative spread: Spreads by stolons to form clumps, sometimes 1 m or more across.

Longevity: Indefinite.

Primary juvenile period:

Flowers: White-lavender, throughout the year.

Fruit/seed: Achene, flattened, about 2 mm long with 4-6 rigid spreading spines 1-4 mm long.

Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed. In western NSW growth occurs at most times of year, but plants may die back during summer-autumn (Cunningham 1981).

Fire response:

Interaction with other organisms: Grazed by stock.

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT NWS CWS SWS NWP SWP; Qld, Vic., S.A.

Distribution Sydney area: Only known from Concord, possibly chance introduction by stock [West Maitland (1908) outside area].

Select locations: Concord (W. Woolls probably 1860s).

Habitat

Habitat:

Altitude: 0-50 m

Annual rainfall: 1000 mm

Typical local abundance:

Vegetation:

Substrate: Heavy soils, moist places.

Exposure:

Conservation

Conservation: Locally extinct.

***Carduus nutans* subsp. *nutans* ***

ASTERACEAE

Nodding Thistle

Life history

Growth form: Herb to 70 cm high with rosettes that often exceed 1 m, and a strong, fleshy taproot (Medd 1984).

Vegetative spread: No, but plants can re-grow from old rootstock (Medd 1984).

Longevity: 2 years. Interference with normal development,, e.g. grazing or spraying, causes the plant to behave as a short-lived perennial (Doing et al. 1969).

Primary juvenile period: 1–2 years depending on emergence relative to winter (Medd 1984).

Flowers: Mauve-red, spring–autumn, but regrowth from old rootstock can flower in winter (Medd 1984). Cold temperatures required to initiate flowering (Doing et al. 1969).

Fruit/seed: Achene 4–5 mm long, with pappus of bristles 15–20 mm long. 250–400 fresh, well-developed seeds per. gram (Doing et al. 1969).

Dispersal, establishment & growth: Diaspore: fruit. Short-distance wind-dispersal from parent plant, long-distance dispersal in fodder, movement of vehicles and stock (Medd 1984). Most fresh seeds germinate 14 days after sowing (Doing et al. 1969). Seed germination strongly stimulated by light, suppressed by green pasture cover; short period of innate dormancy in addition to dormancy induced by soil cover allows seed to survive in soil for up to 20 years (Popay 1987). Seedlings emerge in autumn and spring forming rosettes, but require several weeks of low winter temperature to initiate stems for flowering (Medd 1984).

Fire response:

Interaction with other organisms: Aggressive competitor of pastures (Medd 1984).

Thistle-head Weevil *Rhinocyllus conicus* and Seed-head Fly *Urophora solstitialis* recently introduced for biological control, successfully limiting seed production (CSIRO Department of Entomology, no date).

Distribution

Status/origin: Naturalised exotic, native to Europe, Asia, N. Africa. Recorded in eastern Australia in late 1940s (Medd 1984), establishment over present range marked by unusual sequence of wet years 1950–1961 (Doing et al. 1969).

Botanical subregions: NT CT ST NWS CWS SWS; Vic., Tas., S.A., W.A.

Distribution Sydney area: Oberon area.

Select locations: Black Springs (1950, only Herbarium record).

Habitat

Habitat: Cultivated paddocks, sometimes roadsides and riverbanks (Doing et al. 1969).

Altitude: 1000 m **Annual rainfall:** 800 mm

Typical local abundance:

Vegetation: Thistle communities in cultivated pastures, roadside and riverbank vegetation mainly with *Cirsium vulgare*, *Onopordum acanthium*, *Carduus tenuiflorus*, *C. pycnocephalus*, *Silybum marianum* (Doing et al. 1969).

Substrate: Agricultural soils, fertile. Moist climate and basalt soils (Doing et al. 1969).

Exposure:

Conservation

Conservation: Proclaimed noxious weed in NSW (Medd 1984). Control can be achieved preventing seed germination by maintaining vegetation cover (Popay 1987).

***Carduus pycnocephalus* ***

ASTERACEAE

Slender Thistle

Life history

Growth form: Herb to 80 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Purple-pink, October–November.

Fruit/seed: Achene 4–5 mm long, with pappus of bristles 10–14 mm long, mature November–December.

Dispersal, establishment & growth: Diaspore: fruit. Animal, water and wind-dispersed (Carr et al. 1992).

Fire response:**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe.**Botanical subregions:** NC CC SC CT ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., W.A.**Distribution Sydney area:** Western Sydney and Bathurst area.**Select locations:** Richmond, Liverpool (1909), Mt Annan, Bowral, Bathurst.**Habitat****Habitat:** Pastures, roadsides, wastelands and cultivation.**Altitude:** 0–1000 m**Annual rainfall:** 700–1200 mm**Typical local abundance:** Occasional.**Vegetation:****Substrate:** Clay soil from shales, basalt.**Exposure:****Conservation****Conservation:** Weed of pastures roadsides, wastelands and cultivation.***Carduus tenuiflorus* *** (*Carduus pycnocephalus*)**ASTERACEAE**

Winged Slender Thistle

Life history**Growth form:** Herb 50–150 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Purple, October–November.**Fruit/seed:** Achene 4–5 mm long, with pappus of bristles 11–13 mm long.**Dispersal, establishment & growth:** Diaspore: fruit. Animal, water and wind-dispersed (Carr et al. 1992).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe.**Botanical subregions:** CC SC NT CT ST NWS CWS SWS NWP SWP SFWP; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:** Bathurst area.**Select locations:** Flemington Saleyards (1968), Tarana (1962).**Habitat****Habitat:** Weed of pastures, roadsides, wasteland and cultivation.**Altitude:** 0–1000 m**Annual rainfall:** 1000 mm**Typical local abundance:** Occasional–frequent.**Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Weed of pastures, roadsides, wasteland and cultivation.***Carthamus lanatus* *****ASTERACEAE**

Saffron Thistle

Life history**Growth form:** Herb to 1 m high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Yellow–cream with dark veins, late spring–early summer.**Fruit/seed:** Achene 5–6 mm long, with pappus of stiff bristles 7–10 mm long.**Dispersal, establishment & growth:** Diaspore: fruit. Animal, water and wind-dispersed (Carr et al. 1992), and as a contaminant in grain, hay and wool. Germinates autumn–early

winter (Parsons 1973). Rosettes form in late spring and erect growth in October. Germinates within 2 years but dormancy can last up to 8 years, most seed that germinates lies in the top 5 cm of soil (Gorham 1986).

Fire response:

Interaction with other organisms: Food plant of Pacific Black Duck *Anas superciliosa*, Grey Teal *Anas gibberifrons* (Barker & Vestjens 1989,1990). Flowers and seed eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).

Distribution

Status/origin: Naturalised exotic, native to Europe, first naturalised in Australia in 1887 (Gorham 1986).

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Mainly western Sydney.

Select locations: Ashfield, Oakville, Penrith, Casula, Campbelltown, Jamberoo, Barralier, Bathurst (1904).

Habitat

Habitat: Wasteland.

Altitude: 0–1500 m **Annual rainfall:** more than 700 mm

Typical local abundance: Frequent.

Vegetation: Cultivated paddocks.

Substrate: Overgrazed paddocks with poor fertility and poor soil structure resulting from too-frequent cropping. Recorded on saline sites in western NSW (Semple 1993).

Exposure:

Conservation

Conservation: Its prickly nature restricts stock grazing and reduces carrying capacity. Recognised as weed by Department of Agriculture in 1854 (Gorham 1986). A declared noxious weed in some shires (Harden 1992)

***Carthamus tinctorius* ***

ASTERACEAE

Safflower

Life history

Growth form: Herb to 60 cm high. Erect, woody-stemmed, 60–120 cm high with strong taproot to 2 m deep (Colton 1988).

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Red, orange, yellow, white, winter–summer. Abundant pollen and nectar, attracts bees but the flowers are mostly self-pollinated; individual flowers open for 2–3 days, plants flower 2–3 weeks (Colton 1988).

Fruit/seed: Achene 7–8 mm long, pappus absent or minute, matures December–January. Each flower head can produce up to 100 seeds but more commonly 25–50 (Colton 1988). Sharp spines on leaves and bracts of some forms deter predators, e.g. kangaroos (Colton 1988).

Dispersal, establishment & growth: Diaspore: fruit. Winter–spring growing, no seed dormancy; development influenced by temperature, early growth slow, several weeks in rosette stage (Colton 1988).

Fire response:

Interaction with other organisms: Predators include Cutworm caterpillars, green peach aphids, plum aphids (Colton 1988).

Distribution

Status/origin: Exotic, native to Europe. Cultivated in Australia since 1950s as a dryland crop for its oil-yielding seeds; grown for centuries in China, India, the Near East and N Africa mainly for red dye, carthamin, which was extracted from dried and ground petals; widely used to colour food and clothing (Colton 1988).

Botanical subregions: CC CWS SWS SWP NFWP; Qld, Vic., Tas., W.A.

Distribution Sydney area: Glenfield (1967).

Select locations: Glenfield only record for area.

Habitat

Habitat: Roadsides, railway line.

Altitude: 0–50 m

Annual rainfall: 800 mm

Typical local abundance: Rare.

Vegetation:

Substrate: Grows best on neutral-alkaline soil, with good drainage, does not tolerate water-logging; tolerates salinity (Colton 1988).

Exposure:

Conservation

Conservation: Not likely to be naturalised, localised establishment from spilt grain.

Cassinia aculeata

ASTERACEAE

Dolly Bush

Life history

Growth form: Shrub 1–2.5 m high, with rusty hairs on stem.

Vegetative spread: No.

Longevity: Plants up to ? 36 years old (Lion Is) but no re-establishment in absence of fire or disturbance.

Primary juvenile period:

Flowers: November–March.

Fruit/seed: Achene 0.8 mm long, pappus 2 mm long.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response: Killed by high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).

No seedlings recorded less than 1 year after fire (Purdie 1977).

Interaction with other organisms: Contact with flowering plant causes dermatitis and eye irritation in humans (Hurst 1942).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST CWS SWS SWP; Vic., S.A., Tas.

Distribution Sydney area: Coast and Mountains.

Select locations: Budgewoi, Woy Woy, Berowra, Como, Menangle, Kurrajong Heights, Woodford, Mt Victoria, Clarence, Kanangra, Hilltop, Bundanoon.

Habitat

Habitat:

Altitude: 0–1000 m

Annual rainfall: above 1000 mm

Typical local abundance: Frequent–occasional.

Vegetation: Sclerophyll forest, woodland and heath.

Substrate: Variable, sandy or gravelly soil from sandstone, shale, basalt, fertile–infertile, well-drained.

Exposure: Mid-shade–full sun.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.

Cassinia arcuata

ASTERACEAE

Sifton Bush, Chinese Shrub

Life history

Growth form: Shrub up to 2 m high, with short taproot and numerous stout lateral roots to 30 cm deep (Parsons & Cuthbertson 1992).

Vegetative spread: No.

Longevity: Probably 10–20 years.

Primary juvenile period: 2–3 years (Parsons & Cuthbertson 1992).

Flowers: March–April.

Fruit/seed: Achene, 0.8 mm long with pappus of bristles 2 mm long, mature March–April.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed. Germination in winter. Non-dormant fraction 60–80 % at 1 year old, 0.3 % at 15 years. Coloniser of bare

sites. Seedlings established on soil surface, and reached 60 mm in height after 3 months. May reach 600 mm in the first year in favourable sites. Seedlings are unpalatable to stock. Plants reach 2 m in height in 5–10 years (Campbell et al. 1990) (McGowen et al. 1990). Drought-resistant.

Fire response: Plants killed, followed by seedling recruitment.

Interaction with other organisms: Unpalatable to stock and may compete with pasture species. 'Chinese Shrub' originates from its use as roofing material by Chinese on the Victorian Goldfields in the 1850s (Parsons 1973).

Distribution

Status/origin: Native.

Botanical subregions: CC CT ST NWS CWS SWS NWP SWP SFWP; Vic., S.A., W.A.

Distribution Sydney area: Mainly west of area, Bathurst–Orange — though early records for Wyong and Homebush suggest that it is indigenous to some coastal areas.

Select locations: Wyong (1900), Marayong, Duck River, Homebush (1894), Wolgan Gap, Bathurst, Ophir, Mullions Range.

Habitat

Habitat: Coloniser of bare sites, in woodland, along roadsides, overgrazed pastures.

Altitude: 0–1000 m **Annual rainfall:** 600–1200 mm

Typical local abundance: Frequent–occasional.

Vegetation: Eucalyptus woodland, e.g. *Eucalyptus macrorhyncha*, *E. melliodora*, mid-stratum.

Substrate: Low-nutrient soils on sandstone. Acid stony soils, on quartzite, shale; infertile. Watertable permanently low, moisture supply intermittent, fresh. Seedling growth depressed by lime (Campbell et al. 1990). Recorded on saline sites in western NSW (Semple 1993).

Exposure: Exposed–indifferent; light–no shade.

Conservation

Conservation: A native species reported to have expanded as a result of pasture deterioration after the 1982 drought (Campbell et al. 1990). Vulnerable in Western Sydney (Benson & McDougall 1991). A natural coloniser of disturbed sites such as mine dumps.

Cassinia aureonitens

ASTERACEAE

Life history

Growth form: Shrub 2–3 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Cream–yellow, November–March, peak November–December.

Fruit/seed: Achene 0.5 mm long, with pappus of bristles 2 mm long.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT.

Distribution Sydney area: Coast and Mountains.

Select locations: Wollombi, Wisemans Ferry, Mooney Mooney Creek, Cheltenham, Cooks River, Kurrajong Heights, Mt Wilson, Yerranderie, Thirlmere, Albion Park.

Habitat

Habitat: Forest and woodland on hillsides and gullies.

Altitude: 0–1000 m **Annual rainfall:** above 800 mm

Typical local abundance: Frequent–occasional.

Vegetation: Mid-stratum, forest and woodland, e.g. with *Eucalyptus sclerophylla*, *E. piperita*, *E. quadrangulata*, with shrubby understorey, rarely in heath.

Substrate: Sandstone, shale, basalt, fertile–infertile. Watertable mostly low, moisture supply intermittent, non-saline.

Exposure: Sheltered sites, mid-shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.

Cassinia compacta

ASTERACEAE

Life history

Growth form: Woody shrub 2–3 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, spring–summer.
Fruit/seed: Achene 0.5 mm long, pappus of bristles 2 mm long.
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.
Fire response: Probably killed.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT CT CWS; Qld.
Distribution Sydney area: Mainly coast, localised.
Select locations: Colo Heights, Mt White, Cowan Creek, Lithgow, Fitzroy Falls.

Habitat

Habitat: Steep sheltered slopes.
Altitude: 0–1000 m **Annual rainfall:** above 800 mm
Typical local abundance:
Vegetation: Mid-stratum, eucalypt forest, edge of rainforest.
Substrate: Sandstone with shale influence, infertile soil. Watertable mostly low, moisture supply intermittent.
Exposure: Sheltered sites, mid-shade.

Conservation

Conservation: Uncommon, southern limit Fitzroy Falls.

Cassinia cunninghamii

ASTERACEAE

Life history

Growth form: Shrub to 1–1.5 m high, stem woolly with greyish-white hairs. Leaves have a spicy liquorice aroma when crushed (P. Hind pers. comm.).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, December–February.
Fruit/seed: Achene, 0.5 mm long, with pappus of bristles 1.5 mm long.
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed. Can establish from seed in absence of disturbance possibly due to tolerance of shade and drought (Ladd 1988). Medium growth rate.
Fire response: Killed, established from widely dispersed propagules (Ladd 1988).
Interaction with other organisms: Seed eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC CT CWS.
Distribution Sydney area: Colo River and north-west of area.
Select locations: Mt Monundilla, Boorai Ridge, Colo Heights, St Albans, Mount Manning, Gaspers Mountain, Newnes Plateau.

Habitat

Habitat: Eucalypt open-forest on sandstone.
Altitude: 0–1000 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Frequent–occasional.
Vegetation: Eucalypt open-forest, e.g. with *Eucalyptus crebra*, *E. punctata*, *E. paniculata* and dry shrubby understorey, e.g. with *Dodonaea triquetra*, *Oxylobium ilicifolium*, *Acacia terminalis*.

Substrate: Sandstone with shale influence. Intolerant of waterlogging.

Exposure:

Conservation

Conservation: Conservation status unknown.

Cassinia denticulata

ASTERACEAE

Life history

Growth form: Shrub 0.7–2 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Pale yellow–white, October–January.

Fruit/seed: Achene, 0.6 mm long, with pappus of bristles 2 mm long.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response: Killed by high-intensity fire (1/1994) at Lane Cove, no seedlings seen (P. Kubiak pers. comm.). Flowered in area (at KCNP) burnt 3 years previously.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC CT.

Distribution Sydney area: Coast and Blue Mountains.

Select locations: Bucketty, Berowra, St Ives, Bradleys Head, Woronora River, Bulli Pass, Kurrajong Heights, Blackheath, Newnes SF, Hilltop, Fitzroy Falls.

Habitat

Habitat: Hillsides and gullies.

Altitude: 0–1000 m

Annual rainfall: above 1000 mm

Typical local abundance: Frequent–occasional.

Vegetation: Mid-stratum, forest and heath with shrubby understorey, e.g. with *Eucalyptus gummiifera*, *E. piperita*, *E. sicberi*, *E. capitata* or *Angophora costata*.

Substrate: Sandy, infertile soils from sandstone. Watertable mostly low, moisture supply intermittent, non-saline.

Exposure: Sheltered sites.

Conservation

Conservation: Endemic to Sydney area, conservation status unknown.

Cassinia laevis

ASTERACEAE

Cough Bush

Life history

Growth form: Shrub to 3 m high with white-woolly stems.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White, November–January.

Fruit/seed: Achene 0.8 mm long, with pappus of bristles 2 mm long.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC NT CT ST NWS CWS SWS NWP SWP NFWP; Qld, S.A.

Distribution Sydney area: Currant Mountain.

Select locations: Currant Mountain (1954).

Habitat

Habitat: Upper slopes.

Altitude: 600 m **Annual rainfall:** 800 mm
Typical local abundance: Frequent.
Vegetation: Mid-stratum.
Substrate: Sandstone, infertile soil.
Exposure:

Conservation: Conservation status unknown.

Conservation

Cassinia leptcephala subsp. *leptcephala*

ASTERACEAE

Growth form: Large robust woody shrub to 3 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pale yellow, October–January.
Fruit/seed: Achene 0.6 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Life history

Status/origin: Native.
Botanical subregions: NC CC NT.
Distribution Sydney area: coast (to coast and Tablelands of N.S.W.).
Select locations: Specimens unavailable.

Distribution

Habitat:
Altitude: **Annual rainfall:**
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Habitat

Conservation: Rare, not well known.

Conservation

Cassinia longifolia

ASTERACEAE

Growth form: Aromatic sticky shrub 1.2–2.5 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: March–April.
Fruit/seed: Achene 0.8 mm long, with pappus of bristles 2–3 mm long, mature March–April.
Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.
Fire response: Seedlings not recorded within 1 year of fire (Purdie 1977).
Interaction with other organisms:

Life history

Status/origin: Native.
Botanical subregions: CC SC CT ST CWS SWS; Vic., Tas.
Distribution Sydney area: Coast, Blue Mountains, Orange.
Select locations: Arncliffe (1893), Penshurst, Royal NP, St Marys, Razorback, Lawson, Mt Tomah, Orange, Mt Canobolas, Cadia, Mt Jellere, Kangaloon (P. Kodala pers. comm.).

Distribution

Habitat:

Habitat

Altitude: 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Occasional–rare.**Vegetation:** Mid-stratum, eucalypt woodland, e.g. with *Eucalyptus macrorhyncha*, or open-forest to tall open-forest, e.g. *Eucalyptus cytharocarpa*, *E. fastigata*, *E. radiata* (P. Kodala pers. comm.)**Substrate:** Shale, basalt, sandstone with calcareous influence, fertile soils. Watertable permanently low, moisture supply intermittent, non-saline.**Exposure:****Conservation****Conservation:** Vulnerable in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.***Cassinia quinquefaria*****ASTERACEAE****Life history****Growth form:** Shrub 1–3 m high, stems olive or yellowish, usually resinous.**Vegetative spread:** No.**Longevity:****Primary juvenile period:****Flowers:** White, January–May, peak April.**Fruit/seed:** Achene 0.8 mm long with pappus of bristles 2 mm long, mature March–August.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.**Fire response:****Interaction with other organisms:** Tested positive for anti-tumour activity (inhibited sarcoma), no alkaloids (Collins et al. 1990).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic.**Distribution Sydney area:** Mostly western parts of the area.**Select locations:** Kogarah (1894), Razorback, Mt Annan, Cambewarra, Mt Victoria, Newnes Junction, Capertee, Sofala, Mullion Range, Hilltop, Berrima, Wombeyan Caves.**Habitat****Habitat:** Open sites in eucalypt forest and woodlands.**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent–occasional–rare.**Vegetation:** Forests and woodland, e.g. with *Eucalyptus pilularis*, *E. resinifera*, and woodland, e.g. with *Eucalyptus crebra*, *E. tereticornis*.**Substrate:** Clay loam on hale, fertile. Intolerant of waterlogging.**Exposure:** Open sites.**Conservation****Conservation:** Vulnerable in Western Sydney (Benson & McDougall 1991), but probably conserved elsewhere.***Cassinia* species D****ASTERACEAE****Life history****Growth form:** Shrub to 2 m high, stems olive or red with soft hairs, leaves sticky (Harden 1992).**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** At any time of year but mainly summer–autumn (Harden 1992).**Fruit/seed:** Achene 0.8 mm long, with pappus of bristles 2–2.5 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

		Distribution
Status/origin: Native.		
Botanical subregions: NC CC SC CT ST NWS CWS SWS.		
Distribution Sydney area:		
Select locations: Specimens unavailable.		
		Habitat
Habitat:		
Altitude:	Annual rainfall:	
Typical local abundance:		
Vegetation: Sclerophyll forest (Harden 1992).		
Substrate: Stony soils (Harden 1992).		
Exposure:		
		Conservation
Conservation: Conservation status unknown.		

Cassinia trinerva

ASTERACEAE

		Life history
Growth form: Shrub or tree to 8 m high.		
Vegetative spread:		
Longevity:		
Primary juvenile period:		
Flowers: Creamy-white, summer–autumn.		
Fruit/seed: Achene 0.5 mm long, with pappus of bristles 2 mm long.		
Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.		
Fire response: Probably killed.		
Interaction with other organisms:		
		Distribution
Status/origin: Native.		
Botanical subregions: NC CC SC NT CT ST CWS; Vic., Tas.		
Distribution Sydney area: Southern Highlands and southwest of area.		
Select locations: Bulli, Razorback, Burragorang, Robertson (P. Kodela pers. comm.), Kangaroo Valley, Jenolan Caves (1899).		
		Habitat
Habitat: Moist eucalypt forest, rainforest.		
Altitude: 0–900 m	Annual rainfall: above 700 mm	
Typical local abundance: Occasional.		
Vegetation: Mid stratum in moist eucalypt forest and edge of disturbed rainforest, e.g. with <i>Eucalyptus quadrangulata</i> . Mixed cool temperate/warm temperate rainfores, where there are light gaps (P. Kodela pers. comm.)		
Substrate: Shale and silty soils; basalt (P. Kodela pers. comm.).		
Exposure: Sheltered sites.		
		Conservation
Conservation: Conservation status unknown.		

Cassinia uncata

ASTERACEAE

Sticky Cassinia

		Life history
Growth form: Sticky shrub 1–3 m high.		
Vegetative spread:		
Longevity:		
Primary juvenile period:		
Flowers: White–straw-coloured, March.		
Fruit/seed: Achene 0.6 mm long, with pappus of bristles 2 mm long.		
Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.		
Fire response:		
Interaction with other organisms:		

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT ST NWS CWS SWS SWP; Qld, Vic., S.A.

Distribution Sydney area: Coast and north western Sydney.

Select locations: Wamberal, Barrenjoey (L.McD.), Galston, Lindfield, Tempe (1899), Castlereagh SF, Windsor, Maroota.

Habitat

Habitat:

Altitude: 0–200 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Open-forest, e.g. with *Eucalyptus piperita*, *E. eximia*, *Angophora bakeri* or woodland, e.g. with *Eucalyptus polyanthemos*, *E. macrorhyncha* (Benson & Keith 1990).

Substrate: Sandstone, shale, Tertiary alluvium. Soil fertile–infertile. Watertable permanently low, moisture supply intermittent, non-saline.

Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991). Conservation status elsewhere unknown.

Celmisia longifolia species complex

ASTERACEAE

Snow Daisy

Life history

Growth form: Herb with dense-tufted basal stock.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Florets pink or white, February.

Fruit/seed: Achene c. 5 mm long with pappus of barbellate bristles, February.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CT ST.

Distribution Sydney area: Upper Blue Mountains, mainly Newnes Plateau.

Select locations: Blackheath, Newnes State Forest.

Habitat

Habitat: Swamp and seepage areas, moist cliff faces.

Altitude: 1000–1200 m

Annual rainfall: 1000 mm

Typical local abundance: Frequent.

Vegetation: Newnes Plateau shrub-swamps or less commonly Blue Mountains sedge swamps, e.g. with *Gymnoschoenus sphaerocephalus*, *Baeckea linifolia*, *Grevillea acanthifolia*, *Gleichenia*.

Substrate: Often on margins of poorly-drained, peaty swamps, infertile. Watertable permanently high.

Exposure: Full sun.

Conservation

Conservation: Restricted, probably inadequately conserved. Habitat vulnerable to disturbance.

Centaurea calcitrapa *

ASTERACEAE

Star Thistle

Life history

Growth form: Erect herb with radical leaves.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Florets pale purple or pink, spring–summer.

Fruit/seed: Achene 3 mm long, no pappus.

Dispersal, establishment & growth: Diaspore: fruit, animal and water-dispersed (Carr et al. 1992).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe, Africa and Asia.

Botanical subregions: NC CC NT CT ST NWS CWS SWS SWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Widespread but rare.

Select locations: Haberfield (1920), Penrith (1912), Lithgow (1967).

Habitat

Habitat: Wasteland.

Altitude: 0–1000 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent.

Vegetation: Grassland.

Substrate: Recorded on saline sites in western NSW (Semple 1993).

Exposure:

Conservation

Conservation: A declared noxious weed in many NSW shires (Harden 1992), but rare in Sydney area.

***Centaurea melitensis* ***

ASTERACEAE

Maltese Cockspur, Cockspur Thistle

Life history

Growth form: Herb to 1 m high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, mainly spring–summer. Very late September–October (Price).

Fruit/seed: Achene 2.5 mm long, pappus of bristles 2.5 mm long.

Dispersal, establishment & growth: Diaspore: fruit, animal and water-dispersed (Carr et al. 1992).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Woy Woy, Penshurst, Cooks River, Richmond, The Oaks, Jenolan Caves, O'Connell, Bullio, Exeter, Wingello (1899).

Habitat

Habitat: Disturbed areas, pastures, roadsides, stock routes and cultivated land.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance:

Vegetation:

Substrate: Gravel pits, poultry yards.

Exposure:

Conservation

Conservation: Weed of disturbed areas with most Herbarium records collected 1900–1930.

***Centaurea solstitialis* ***

ASTERACEAE

St Barnaby's Thistle

Life history

Growth form: Herb to 1 m high.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, late spring–summer (Parsons 1973).

Fruit/seed: Achene 2.5 mm long — two kinds: one with pappus of bristles to 5 mm long, suitable for wind-dispersal, the other with or without reduced pappus; spread by water and as contaminant of agricultural produce, vehicles, wool, fodder (Parsons 1973).

Dispersal, establishment & growth: Diaspore: fruit, wind, water-dispersed, human-dispersed. Germinates in autumn, remaining a rosette during winter and developing quickly to diameter of 30 cm as temperature rises in spring. Flowering commences in November and continues through summer, 'seeds' formed over long period of 4–5 months (Parsons 1973).

Fire response:

Interaction with other organisms: Spines on flower-heads deter grazing by sheep (Parsons 1973).

Distribution

Status/origin: Naturalised exotic, native to Europe, W Asia.

Botanical subregions: CC SC NT CT ST NWS CWS SWS NWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Widespread but sporadic.

Select locations: Denistone, Flemington Saleyards, Richmond, Bathurst (1904).

Habitat

Habitat: Weed of disturbed sites, pastures and cultivated land.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Rare.

Vegetation: Pastures and cultivated lands.

Substrate: Pasture soils.

Exposure:

Conservation

Conservation: Naturalised weed, widespread but sporadic, in pastures and cultivated land. Declared noxious in some NSW shires.

Centipeda cunninghamii

ASTERACEAE

Common Sneeze Weed

Life history

Growth form: Herb c. 20 cm high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Summer.

Fruit/seed: Achene 2 mm long, no pappus.

Dispersal, establishment & growth: Diaspore: fruit, leaf growth and flowering occurs mainly in the warmer months, with plants remaining semi-dormant in winter (Cunningham et al. 1981).

Fire response:

Interaction with other organisms: Sparingly grazed by stock, possibly strongly aromatic. Odour emitted by plants when crushed deters grazing; powdered leaves are said to act like snuff, hence common name (Cunningham et al. 1981).

Distribution

Status/origin: Native.

Botanical subregions: CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A., N.Z.

Distribution Sydney area: Coast, west of mountains.

Select locations: Pennant Hills, Windsor, Glenfield, Shoalhaven River, Capertee, Rydal (1897), Winburndale, Hilltop.

Habitat

Habitat: Wet places, river flats.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance:

Vegetation:**Substrate:** Alluvial soil, damp areas subject to flooding.**Exposure:** Full sun.**Conservation****Conservation:** Conservation status unknown.***Centipeda minima* var. *minima*****ASTERACEAE**

Spreading Sneeze Weed

Life history**Growth form:** Small aromatic herb.**Vegetative spread:** No.**Longevity:** Short-lived, 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Small yellow flowers, January–February.**Fruit/seed:** Achene 2 mm long, pappus absent, January–April.**Dispersal, establishment & growth:** Diaspore: fruit, possibly water-dispersed. Coloniser.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS SWS NWP SWP NFWP; Qld, Vic., Tas., N.T., S.A., W.A., N.Z., Asia to Afghanistan.**Distribution Sydney area:** Widespread.**Select locations:** Hornsby, Devlins Creek, Glenfield, Elderslie, Cambewarra, Colo River, Yarramundi, Thirlmere Lakes, Cocks River, Berrima.**Habitat****Habitat:** Floodplain wetlands, lagoon edges.**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Rare–frequent.**Vegetation:** Herbland, e.g. with *Persicaria lapathifolia*, *Xanthium chinense*.**Substrate:** Mainly clay and alluvium, fertile soil, watertable mostly high.**Exposure:** Full sun.**Conservation****Conservation:** Vulnerable in Western Sydney (Benson & McDougall 1991). Status elsewhere unknown.***Chondrilla juncea* *****ASTERACEAE**

Skeleton Weed

Life history**Growth form:** Herb 0.5–1 m high, with long taproot to depth of 3 m (Parsons 1973), purplish radical leaves until stem develops, then almost leafless.**Vegetative spread:** Local spread by cultivation, regrowth from taproot can occur from depth of more than 1 m; cutting of taproot stimulates growth of new rosettes at almost any time of year (Parsons 1973).**Longevity:** Biennial–perennial.**Primary juvenile period:** Less than 1 year, although on poor soils flowering sometimes does not occur in the first year (Parsons 1973).**Flowers:** Yellow, summer (January–April).**Fruit/seed:** Achene 8–10 mm long, with stalked pappus of toothed bristles 6–7 mm long, mature January–April. Seed production is prolific, one plant can produce 15,000 seeds in a season, with up to 90% germination depending on conditions; high summer temperature results in maximum seed production; seed is relatively short-lived, less than 3 years (Parsons 1973).**Dispersal, establishment & growth:** Diaspore: fruit. Animal, water, vegetative, and wind dispersed (Carr et al. 1992). Germinates after autumn rains, rosettes form and grow slowly

over winter while the taproot develops rapidly (more than 1 cm/day), each taproot produces 2–3 rosettes, stem is produced in spring and rosette leaves die leaving the plant almost leafless; seedlings sensitive to competition, particularly for light (Parsons 1973).

Fire response:

Interaction with other organisms: Troublesome weed to wheat-growers, tough wiry stems have prevented harvesting of wheat and forced changes in farming practice; rosettes grazed by sheep (Parsons 1973).

Distribution

Status/origin: Naturalised exotic, native to Europe and W. Asia. First recorded in Australia near Wagga in 1917, probably introduced in vine stocks from southern Europe (Parsons 1973).

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP SFWP; Qld, Vic., S.A., W.A.

Distribution Sydney area: Widespread but mainly western part of the area.

Select locations: Emu Plains, Grose River, Albion Park, Goodmans Ford, Menangle Park, Linden, Lithgow, Bathurst, Orange (1935).

Habitat

Habitat: Creekbanks.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Rare.

Vegetation: Open plant communities (Parsons 1973). On creekbanks with *Sigesbeckia*, *Persicaria*, *Solanum*.

Substrate: Deep, light-textured soils needed for development of long taproot; requires moderate calcium and phosphorous levels; can withstand long periods of drought (Parsons 1973).

Exposure: Exposed, full sun.

Conservation

Conservation: Declared noxious weed in several States and part of NSW. Not invasive of bushland.

Chrysanthemoides monilifera* subsp. *rotundata*

ASTERACEAE

Bitou Bush

Life history

Growth form: Large sprawling shrub to 1.5 m high with extensive tap and lateral root system, more aggressive than *C. subsp. monilifera*, more extensive root system and more difficult to control (Parsons & Cuthbertson).

Vegetative spread: Arching branches root vigorously where they touch the sandy substrate (R. Buchanan pers. comm.), regrows from cut stump (Dellow 1988).

Longevity: About 7–8 years.

Primary juvenile period: Primary juvenile period about 2 years.

Flowers: Yellow, May–July, but intermittent all year.

Fruit/seed: Fleishy berry 6–8 mm diam., black when ripe, mature mainly June–August.

Dispersal, establishment & growth: Diaspore: black fleshy 1-seeded fruit, mature in summer, mainly bird-dispersed, also spread in faeces of rabbits, foxes and cattle; ants eat fleshy skins and discard the seeds; spread in contaminated gravel in Victoria; fruit and seeds dispersed by running water; soil-stored seed up to 9500/m²; 60% viability, some dormant for at least 10 years (Parsons & Cuthbertson 1992). Seeds germinate at any time of year but mostly autumn. Most seeds retain viability for at least 2 years with some up to 4 years (Dellow 1988).

Fire response: Mature plants resprout after fire (Dellow 1988). Generally resprouts strongly after fire; dense growth of seedlings can crowd out other plant species (Parsons & Cuthbertson 1992).

Interaction with other organisms: Leaf litter and fruit leachates inhibit the germination and growth of some native plant species; can form dense stands, replacing native species thus destroying habitat of native birds and animals (Parsons & Cuthbertson 1992). Eliminated when grazed or trampled by livestock — is not a problem on agricultural land (Dellow 1988). Flower and fruit production reduced 50% and 70% by introduction of Bitou Tip Moth *Comostolopsis germana* in 1990 (Tanner & Nolan 1993).

Distribution

Status/origin: Naturalised exotic, native of S. Africa. Introduced in mid 19th century, being dispersed in ships' ballast dumped on the Hunter River banks 1908 (Parsons & Cuthbertson 1992).

Botanical subregions: NC CC SC; LHI, Qld.

Distribution Sydney area: Coastal beaches and north of Sydney.

Select locations: Palm Beach, La Perouse, Port Kembla (1965), Shellharbour.

Habitat

Habitat: Sand dunes and forest margins near beaches.

Altitude: 0–100 m **Annual rainfall:** above 1200 mm

Typical local abundance: Frequent–dominant.

Vegetation: Sand dune vegetation, e.g. with *Leptospermum laevigatum*, *Acacia longifolia*, *Correa alba*.

Substrate: Sand dunes and sand-mined areas, infertile, well-drained. Can withstand dry conditions; coloniser of sand dunes where it competes successfully with native species (Dellow 1988).

Exposure: Full sun.

Conservation

Conservation: Used as a secondary stabilising species on sand drift and mined areas in 1946–1968 but use stopped in 1971; poses a threat to native sand dune vegetation and drastically alters habitat for wildlife. Estimated to occur along 60% of the NSW coast including 12 national parks and 9 nature reserves (Parsons & Cuthbertson 1992), does not persist in cultivated areas (Dellow 1988). Selective aerial spraying techniques that do not kill native species are being developed by John Toth, Dept. of Agriculture, Biological and Chemical Research Institute, Rydalmere. Spray in winter, very low rate (M. Clarke pers. comm.).

Chrysanthemoides monilifera* subsp. *monilifera* **ASTERACEAE**

Boneseed

Life history

Growth form: Upright shrub to 3 m high; shallow rooted, no distinct tap root (Parsons 1973).

Vegetative spread: Regrows strongly from cut stumps (Parsons 1973).

Longevity: About 7–8 years.

Primary juvenile period: More than 18 months (Parsons 1973).

Flowers: Yellow, August–December.

Fruit/seed: Fleshy berry 6–8 mm diam., black when ripe; mature in summer (Parsons & Cuthbertson 1992).

Dispersal, establishment & growth: Diaspore: black fleshy 1-seeded fruit, mainly bird-dispersed, also spread in faeces of rabbits, foxes and cattle; ants eat fleshy skins and discard the seeds; spread in contaminated gravel in Victoria; fruit and seeds dispersed by running water (Parsons & Cuthbertson 1992). Fruit reported sold as pea-shooter ammunition (Parsons 1973). Seed moved in soil during roadworks (R. Buchanan pers. comm.). Large soil-stored seedbank, up to 2500/m² (Parsons & Cuthbertson 1992). Seeds germinate at any time of year but mostly autumn; most seeds retain viability for at least 2 years and up to 4–5 years (Dellow 1988), viability increased with increased depth of burial (Parsons & Cuthbertson 1992). Seed quickly germinates after mature plants are removed.

Fire response: Killed by high-intensity fire (1/1994) at Lane Cove, seedlings observed (P. Kubiak pers. comm.). Mature plants killed by fire in Victoria with almost complete germination of weathered seed (Dellow 1988).

Interaction with other organisms: Leaf litter and fruit leachates inhibit the germination and growth of some native plant species; can form dense stands, replacing native species and destroying habitat of native birds and animals (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Naturalised exotic, native to S Africa. Introduced as an ornamental in 1850s, considered naturalised by 1910 (Parsons & Cuthbertson 1992).

Botanical subregions: CC SC CT NFWP SFWP; Vic., Tas., S.A., W.A.

Distribution Sydney area: Coast, western Sydney.

Select locations: Mt Colah (R. Buchanan pers. comm.), Beecroft, Chatswood, Royal Botanic Gardens (1898), Heathcote, Shellharbour, Macquarie Fields, Wallacia, Woodford.

Habitat

Habitat: Coastal vegetation and cleared land.

Altitude: 0–600 m **Annual rainfall:** above 1000 mm

Typical local abundance: Occasional–frequent.

Vegetation: Woodland, heath and disturbed sites.

Substrate: Sandy infertile soils (Parsons 1973), well-drained.

Exposure: Full sun.

Conservation

Conservation: Successfully competes with native vegetation for light (Parsons 1973).

***Chrysocephalum apiculatum* (Helichrysum apiculatum)**

ASTERACEAE

Common Everlasting, Yellow Buttons

Life history

Growth form: Herb to 60 cm high, usually with a woody base.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Bright yellow flowers, at any time of year but mainly spring; peak in October for CC and in April and November for CT.

Fruit/seed: Achene, upper half with bright yellow bristles, March (limited data).

Dispersal, establishment & growth: Optimal germination regime 20°/10°C, germination promoted by light, strong after ripening requirement (dormancy), dormancy broken by high temperature but not cold-stratification or gibberellic acid (Willis and Groves 1991).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread, but not on sandstone areas.

Select locations: Culoul Range, Pennant Hills, Rooty Hill, Rookwood, Badgerys Creek, Mt Annan, Appin, Moss Vale, Lithgow, Winburndale, Orange, Taralga.

Habitat

Habitat: Grassy patches in forests.

Altitude: 0–1000 m **Annual rainfall:** above 700 mm

Typical local abundance: Occasional.

Vegetation: Woodland and open-forest, e.g. with *Eucalyptus tereticornis*, *E. deanei*, *E. mannifera*, *E. radiata*.

Substrate: Clay soils from shales, e.g. Wianamatta Group, fertile. Watertable permanently low, moisture supply intermittent, fresh.

Exposure: No shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.

***Chrysocephalum semipapposum* (Helichrysum semipapposum)**

ASTERACEAE

Clustered Everlasting, Yellow Buttons

Life history

Growth form: Aromatic herb to 60 cm high. Certain forms grade into *H. apiculatum*.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Bright yellow, October–April, peak November.

Fruit/seed: Achene, with barbed bristles, mature March–April.

Dispersal, establishment & growth:

Fire response: Regrowth and suckers from rootstocks and lateral roots, no seedlings recorded less than 1 year after fire (Purdie 1977).

Interaction with other organisms:**Distribution**

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Western and southern Blue Mountains.

Select locations: Mt Kerry, Castle Hill, Hill End, Glanmire, Lithgow, Berrima, Abercrombie, Wombeyan Caves, Kangaroo Valley, Nowra.

Habitat

Habitat: Hills, mountains or isolated rocky rises.

Altitude: 0–1000 m

Annual rainfall: above 900 mm

Typical local abundance: Occasional.

Vegetation: Eucalypt open-forest with herbaceous/grassy understorey. Ground stratum.

Substrate: Clay soils from basalt, shales etc, also limestone. Fertile soil. Watertable permanently low, moisture supply intermittent, fresh.

Exposure: Sheltered situations.

Conservation

Conservation: Rare, only 7/32 specimens collected since 1960, conservation status unknown.

Cichorium intybus* **ASTERACEAE**

Chicory

Life history

Growth form: Rosette herb with stems 30–120 cm high; well-developed tap-root (Lamp & Collet 1989).

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Blue, rarely white, November–April.

Fruit/seed: Achene 2–3 mm long, with minute pappus, mature May.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms: Has been used as a salad, condiment or vegetable.

Distribution

Status/origin: Naturalised exotic, native to Europe, N Africa, Asia. Cultivated for fodder and as a salad vegetable. Root roasted and ground, used to blend with coffee (Lamp & Collet 1989). Since ancient times, used as a medicine for eye ailments and for blood-purifying (Ciba-Geigy 1968–).

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Hornsby, Ermington, Parramatta, Richmond, Menangle (1894), Kiama, Bathurst.

Habitat

Habitat: Common roadside and wasteland weed.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent.

Vegetation: Wasteland weeds.

Substrate: Clay soils.

Exposure: Full sun.

Conservation

Conservation: Weed of disturbed sites. Not invasive of bushland.

Cirsium vulgare* **ASTERACEAE**

Spear Thistle

Life history

Growth form: Biennial, erect herb to 1.5 m high with radical and cauline leaves; long, well developed taproot (Lamp & Collet 1989). Rosette leaves up to 35 cm long, older leaves deeply lobed and armed with spines, taproot branched, fleshy (Parsons & Cuthbertson 1992).

Vegetative spread: No.

Longevity: 2 years.

Primary juvenile period: 1–2 years in fertile soil, but in less fertile conditions may be several years (Klinkhamer & De Jong 1993).

Flowers: Pink–purple, October–January. Ample nectar production, honey is light, pale and candies hard; pollen supply useful because it occurs when other sources are deficient in Yellow Box areas (Lamp & Collet 1989).

Fruit/seed: Achene 3–6 mm long, with pappus of feather-like bristles 2–3 cm long, mature October–April. Up to 200 flower heads and 8000 seeds counted on individual plants (Parsons & Cuthbertson 1992).

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed. Also animal and water-dispersed (Carr et al. 1992). Seeds germinate in autumn; most germinate rapidly with very little dormancy; seedling survival increased by rainfall but susceptible to flooding of root; rosettes withstand cold conditions but seedlings and young rosettes susceptible to drought (Klinkhamer & De Jong 1993). Extensive root system with fleshy storage develops in winter, rosette continues to grow in spring to 60 cm diam. (if rosettes die off in a dry summer, new rosette develops in autumn or winter), during spring of second year a flowering stem is produced from centre of rosette (Parsons 1973).

Fire response: Possibly resprouted after high-intensity fire (1/1994) at Lane Cove; flower buds within 26 weeks (P. Kubiak pers. comm.). Seedlings recorded less than 1 year after fire (Purdie 1977), probably result of post-fire dispersal into the area. Appears after disturbance, probably soil-stored seed (M. Clarke pers. comm.).

Interaction with other organisms: Seed eaten by Black Swan *Cygnus atratus*, Spotted Quail-thrush *Cinclosoma punctatum*, foodplant of Grey Teal *Anas gibberifrons* (Barker & Vestjens 1989, 1990). Flowers and seed eaten by Sulphur-crested Cockatoo *Cacatua galerita* (Lepschi 1993). Spiny stems and leaves make it unpalatable to most stock (Klinkhamer & De Jong 1993), reducing the carrying capacity of paddocks; thick patches provide effective refuge for rabbits, fleshy root used to poison rabbits; spiny leaves and bracts transmit virus diseases between animals; biological control using gall fly is being investigated (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Naturalised exotic, native to N Africa, Europe and Asia. The subject of noxious weed legislation in the 1850s (Parsons & Cuthbertson 1992).

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; LHI, Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Widespread, western Sydney, upper Blue Mountains, Southern Highlands (P. Kodala pers. comm.).

Select locations: Wahroonga, Carlingford (M. Clarke pers. comm.), Mosman (1887), Oakville, Silverdale, Mt Annan, Lake Illawarra, Kangaroo Valley, Mt Wilson (1906), Mt Tomah, Capertee.

Habitat

Habitat: Wetland, river edges, wasteland. Abundant on roadsides, common weed of pastures (Lamp & Collet 1989). Disturbed edges (M. Clarke pers. comm.).

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent.

Vegetation: Pastures, remnant native vegetation. Thistle communities, mainly with *Onopordum acanthium*, *Carduus nutans*, *C. tenuiflorus*, *C. pycnocephalus*, *Silybum marianum* (Doing et al. 1969).

Substrate: Clay soils from shales, basalt, fertile–very fertile; soil rich in nutrients (Ciba-Geigy 1968–). Watertable mostly low. Recorded on saline sites in western NSW (Semple 1993). Less common on sand and soils with humus content more than 30% and almost

absent from pure clay soil; wide range of pH, peaks on almost neutral soil, rare on soil less than 4.8–5.0 pH (Klinkhamer & De Jong 1993).

Exposure: 55% full daylight for highest rate of growth and seed production (Klinkhamer & De Jong 1993).

Conservation

Conservation: Common weed, plentiful throughout the State (Boorman 1921 Herbarium note). Declared noxious weed in some shires of NSW; recognised as weed in Victoria in 1856 (Parsons 1973).

Conyza albida *

ASTERACEAE

Tall Fleabane

Life history

Growth form: Robust, erect herb to 2 m high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: At any time of year, peak April–June.

Fruit/seed: Achene, ovoid, with pappus of minutely barbed bristles, 3 mm long. Mature at any time of year, peak March–April.

Dispersal, establishment & growth: Diaspore: fruit. Wind-dispersed locally and wide-spread, readily colonising disturbed sites. Water and possibly animal-dispersed (Carr et al. 1992).

Fire response: Killed. Seedlings recorded less than 1 year after fire (Purdie 1977), probably recruiting from wind-blown seed.

Interaction with other organisms: Flowers eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).

Distribution

Status/origin: Naturalised exotic, native to N America.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS SWP; LHI, Qld, Vic., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Dee Why, Manly, Ashfield (1916), Bondi, Ingleburn, Campbelltown, Windang, Katoomba, Coffs River, Robertson (P. Kodela pers. comm.), Barrengarry.

Habitat

Habitat: Weed of cultivation, pasture and wasteland.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent.

Vegetation: With other weedy species, or invading undisturbed areas in open sites in woodland.

Substrate: Very fertile–fertile soils on shale, sandstone and metamorphics. Watertable mostly low, moisture supply intermittent, fresh.

Exposure: Light shade–no shade.

Conservation

Conservation: Weed of disturbed sites.

Conyza bilbaoana *

ASTERACEAE

Canadian Fleabane

Life history

Growth form: Robust herb to 2 m high.

Vegetative spread: No.

Longevity: Up to 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, most of the year.

Fruit/seed: Achene with pappus of bristles 2–3 mm long, dispersed at maturity February–April.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to S America.

Botanical subregions: NC CC SC CT ST NWS SWS; Qld, Vic., S.A.

Distribution Sydney area: Mainly upper Blue Mountains and Bathurst area.

Select locations: Morisset (1899), Como (1899), Clarence, Jenolan Caves (1899), Wallerawang, Cudgegong, Yetholme, Hilltop.

Habitat

Habitat: Roadsides and disturbed land.

Altitude: 0–1100 m **Annual rainfall:** above 700 mm

Typical local abundance: Frequent.

Vegetation: With other wasteland weeds.

Substrate:

Exposure:

Conservation

Conservation: Weed of roadsides and disturbed land. Widespread by 1900.

Conyza bonariensis *

ASTERACEAE

Flaxleaf Fleabane

Life history

Growth form: Robust, erect herb to 1 m high.

Vegetative spread: No.

Longevity: Annual.

Primary juvenile period: Less than 1 year.

Flowers: At any time.

Fruit/seed: Achene with pappus of white–pink capillary bristles 3 mm long, mature August–April.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed locally and probably long distance. Coloniser of disturbed sites.

Fire response: Probably killed, fruit within 15 weeks of high-intensity fire (1/1994) at Lane Cove; possibly resprouts after low intensity fire (P. Kubiak pers. comm.).

Interaction with other organisms: Seed eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).

Distribution

Status/origin: Naturalised exotic, native to S America.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; LHI, Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Coastal and western Sydney.

Select locations: Cheltenham, Manly, Como (1887), Little Bay, Cabarita, Windsor, Campbelltown, Albion Park, Bowral.

Habitat

Habitat: Roadsides, pastures and wasteland.

Altitude: 0–800 m **Annual rainfall:** above 700 mm

Typical local abundance: Frequent.

Vegetation: With roadside weeds.

Substrate: Sandy soils. Recorded on saline sites in western NSW (Semple 1993).

Exposure: Full sun.

Conservation

Conservation: Weed of cultivation, pasture and wasteland. Not invasive of bushland.

***Conyza canadensis* var. *canadensis* ***

ASTERACEAE

Canadian Fleabane

Life history**Growth form:** Robust, erect, herb to 1 m high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Throughout the year, flowers cream.**Fruit/seed:** Achene with pappus of bristles 4 mm long.**Dispersal, establishment & growth:** Diaspore: fruit; wind-dispersed.**Fire response:** Resprouts at ground level or below (Fox 1988).**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to N America.**Botanical subregions:** CC SC NT CT ST NWS SWS; LHI, Qld, Vic., Tas., S.A.**Distribution Sydney area:** Widespread, but mainly western Blue Mountains.**Select locations:** Clyde, Glen Davis, Coxs River (1909), Kowmung River.**Habitat****Habitat:** Weed of cultivation, pasture and wasteland.**Altitude:** 0–800 m**Annual rainfall:** 700–1000 mm**Typical local abundance:** Occasional.**Vegetation:** Grassland, disturbed areas, river flats.**Substrate:****Exposure:** Probably no shade.**Conservation****Conservation:** Minor weed of disturbed sites.***Conyza parva* ***

ASTERACEAE

Life history**Growth form:** Erect herb, occasionally to 80 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** White or tinged with mauve, summer–autumn.**Fruit/seed:** Achene with pappus of barbed bristles 2–3 mm long, dispersed at maturity, February–May.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to S America.**Botanical subregions:** NC CC SC NT ST SWS; LHI, Qld, Vic., W.A.**Distribution Sydney area:** Widespread, but mainly suburban area.**Select locations:** Putty, Gosford, Hornsby, Wahroonga, Kurnell (1906), Cronulla, Ashfield, Menangle Park, Hayes Crossing.**Habitat****Habitat:** Open sandy sites.**Altitude:** 0–500 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent.**Vegetation:** Woodland, e.g. with *Angophora floribunda*, *Allocasuarina torulosa*.**Substrate:** Sandy soil, red-brown loam, infertile. Watertable mostly low.**Exposure:****Conservation****Conservation:** Minor weed.

Coreopsis lanceolata *

ASTERACEAE

Coreopsis

Life history**Growth form:** Herb, forming clumps, to 1 m high with radical and cauline leaves.**Vegetative spread:** Spreads by stolons/rhizomes to form clumps.**Longevity:** Indefinite.**Primary juvenile period:****Flowers:** Yellow, summer.**Fruit/seed:** Achene 2–3 mm long, with pappus of 2 awns.**Dispersal, establishment & growth:** Diaspore: fruit, prolific seeder and germinator (anon 1991).**Fire response:** Resprouted and germinated after high-intensity fire (1/1994) at Narrabeen, seedlings observed (P. Kubiak pers. comm.). Resprouts from short woody rhizome (R. Buchanan & M. Clarke pers. comm.).**Interaction with other organisms:** Causes allergy in humans where density is high (Bass 1987).**Distribution****Status/origin:** Naturalised exotic, native of N. America.**Botanical subregions:** CC SC NT CT ST NWS SWP; Qld, Vic.**Distribution Sydney area:** Sydney suburbs and Blue Mountains.**Select locations:** Woy Woy, Northern Peninsula Beaches (M. Clarke pers. comm.), Terrey Hills, Belrose (P. Kodala pers. comm.), Cheltenham (1948), Northbridge, Middle Head, Camden, Linden, Wentworth Falls, Medlow Bath.**Habitat****Habitat:** Roadsides, railway lines and in disturbed areas.**Altitude:** 0–1000 mm**Annual rainfall:** above 700 mm, mainly above

1000 mm

Typical local abundance: Frequent.**Vegetation:** With other roadside weeds, or degraded native vegetation, e.g. *Eucalyptus haemastoma* woodland.**Substrate:** Sandy soils on sandstone, infertile, watertable permanently low, moisture supply intermittent, fresh.**Exposure:** Light shade–no shade.**Conservation****Conservation:** Vigorous weed capable of invading along tracks and stormwater drainage lines in bushland areas (R. Buchanan pers. comm.).**Cosmos bipinnatus ***

ASTERACEAE

Cosmos

Life history**Growth form:** Erect herb 1 m high.**Vegetative spread:** No.**Longevity:** 6 months.**Primary juvenile period:** 3 months.**Flowers:** White, mauve, pink or red, disc yellow, mostly spring, November–May.**Fruit/seed:** Achene with pappus of barbed awns.**Dispersal, establishment & growth:** Diaspore: fruit, possibly wind-dispersed (Carr et al. 1992). Prolific seeder and germinator (Anon 1991).**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Mexico, garden plant.**Botanical subregions:** CC NT CT; Qld.**Distribution Sydney area:** North from Sydney, sporadic.**Select locations:** Erina, Richmond (1902), Royal Botanic Gardens (1902), Hornsby, Cheltenham, Glen Davis.

	Habitat
Habitat: Wasteland.	
Altitude: 0–300 m	Annual rainfall: above 700 mm
Typical local abundance: Occasional.	
Vegetation: Wasteland weeds.	
Substrate: Clay soils from shale, fertile.	
Exposure: Full sun.	
	Conservation
Conservation: Garden plant, occurring occasionally near habitation, not invasive of bush.	

Cotula alpina

ASTERACEAE

Alpine Cotula

Growth form: Stoloniferous, herb.
Vegetative spread: Stoloniferous.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Summer.
Fruit/seed: Achene 1.5–2 mm long with thick wing undifferentiated from body, no pappus.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Life history

Distribution

Status/origin: Native.
Botanical subregions: CT ST; Vic Tas.
Distribution Sydney area: Lithgow.
Select locations: Littleton (near Lithgow) 1893, only record in area and northern limit.
 (Chiefly south from ACT.)

Habitat

Habitat: Wet sites.
Altitude: 900 m **Annual rainfall:** 900 mm || **Typical local abundance:** | |
Vegetation: Sphagnum bogs.	
Substrate: Poorly drained peaty soils.	
Exposure:	

Conservation

Conservation: Probably extinct in Sydney area, last collected in 1893.

Cotula australis

ASTERACEAE

Common Cotula, Carrot Weed

Growth form: Herb usually less than 10 cm high, weakly rooting at nodes.
Vegetative spread: Possibly through rooting at nodes.
Longevity: Annual or short-lived perennial.
Primary juvenile period:
Flowers: August–March.
Fruit/seed: Achene, 1–1.5 mm long, with narrow wing.
Dispersal, establishment & growth: Diaspore: fruit, possibly wind or water-dispersed.
Fire response: Probably killed, fruiting within 15 weeks of high-intensity fire (1/1994) at Lane Cove, seedlings observed (P. Kubiak pers. comm.).
Interaction with other organisms:

Life history

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS NWP SWP; LHI, Qld, Vic., Tas., S.A., W.A., N.Z.

Distribution Sydney area: Sydney suburbs and western Blue Mountains.

Select locations: Pennant Hills, Elizabeth Bay (1888), Cooks River, La Perouse, Burwood, Jenolan Caves, Glen Davis.

Habitat

Habitat: Roadsides, and gardens in Sydney area, cliffines above creek at Glen Davis.

Altitude: 0–600 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent–rare.

Vegetation: Open-forest, also roadsides, lawns, pastures, garden weed.

Substrate: Clay soils. Recorded on saline sites in western NSW (Semple 1993).

Exposure: ? full sun.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991).

Cotula coronopifolia *

ASTERACEAE

Water Buttons

Life history

Growth form: Herb to 20 cm high, erect to spreading, with weak succulent stems rooting from nodes and yellow flowers, plants luxuriant in water forming dense floating masses but diminutive forms on damp land.

Vegetative spread: Spreads over short distances by rooting at nodes.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, August–December.

Fruit/seed: Achene 1.5–2 mm long, winged, mature October–May.

Dispersal, establishment & growth: Diaspore: fruit, animal and water-dispersed (Carr et al. 1992). Growth rate quick. Coloniser of bare mud.

Fire response:

Interaction with other organisms: The crab *Halicarcinus lacustris* shows a distinct association with *C. coronopifolia* (Aston 1977).

Distribution

Status/origin: Native to S Africa (Harden 1992) long regarded also as native to Australia but now described as naturalised exotic (Harden 1992). Reported by Robert Brown to be introduced to Sydney by 1804 (Maiden 1909).

Botanical subregions: NC CC SC ST SWS SWP SFWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Coast, also Cumberland Plain but rare.

Select locations: Norah Head, Cheltenham, Dee Why, Centennial Park, Kogarah (1896), Homebush Bay, Lidcombe, Doonside, Campbelltown, Mt Kembla.

Habitat

Habitat: Wet mud along ephemeral creeks and saline flats.

Altitude: 0–200 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Freshwater or brackish swamp, herbland and sedgeland, e.g. with *Triglochin procera* and saltmarsh, e.g. with *Sarcocornia quinqueflora*, *Samolus repens*.

Substrate: Saline and freshwater areas in still or slow-flowing waters to 45 cm deep and on surrounding damp land mud. Salinity range 0.2–60.0 ppt T.D.S. (Aston, 1977). Soil fertile. Watertable mostly high, moisture supply intermittent. Recorded on saline sites in western NSW (Semple 1993).

Exposure: Full sun.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991). Status elsewhere unknown.

Craspedia canens

ASTERACEAE

Life history

Growth form: Tufted herb 15–65 cm high, with 1–5 flowering scapes, fine white hairs covering the leaves, and thick, spreading roots. Plant in standing water 80 cm high (P. Kodela pers. comm.)

Vegetative spread: Erect herb to 50 cm high.

Longevity: Short-lived (1–3 years).

Primary juvenile period:

Flowers: Yellow, mainly September–December.

Fruit/seed: Achene 1.5–2 mm long with pappus of plumed bristles 4 mm long.

Dispersal, establishment & growth: Wind-dispersed short distances, possibly also water or stock-dispersed (J. Everett pers. comm.).

Fire response:

Interaction with other organisms: Palatable to cattle (J. Everett pers. comm.).

Distribution

Status/origin: Native.

Botanical subregions: CC SC NT CT ST CWS SWS; Qld, Vic.

Distribution Sydney area: Thirlmere, Southern Highlands.

Select locations: Thirlmere, Wingecarribee Swamp.

Habitat

Habitat: Peatland.

Altitude: 0–700 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent.

Vegetation: Eucalypt woodland, grassland and swamps, e.g. with *Carex*. Amongst sedges and along edges of drainage changes on swamp (P. Kodela pers. comm.).

Substrate: Sandy to peaty soils, dry–poorly-drained, fertile–infertile. Often where there is a high watertable, collection from shallow standing water (P. Kodela pers. comm.).

Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).

Craspedia variabilis

ASTERACEAE

Life history

Growth form: Erect herb to 50 cm high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Early spring to early summer.

Fruit/seed: Achene 1.5–2.5 mm long with pappus of plumose bristles 3–6 mm long.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic., S.A., W.A.

Distribution Sydney area: Western Sydney, southern Highlands.

Select locations: Agnes Banks, Long Swamp.

Habitat

Habitat: Eucalypt forest and near swamp margins (P. Kodela pers. comm.).

Altitude: 0–800 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Eucalypt forest, woodland, e.g. with *Eucalyptus parramattensis* and grassland.

Substrate: Clay loams, alluvial or colluvial soils, infertile, watertable mostly high.

Exposure:

Conservation

Conservation: Widespread but probably rare. Conservation status unknown.

***Crassocephalum crepidioides* ***

ASTERACEAE

Thickhead

Life history**Growth form:** Erect herb 50–100 cm high.**Vegetative spread:** No.**Longevity:** Less than 1 year.**Primary juvenile period:** 4 months.**Flowers:** Reddish, April–June.**Fruit/seed:** Achene 2 mm long, with pappus of hairs 8–10 mm long, mature May–June.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:** Killed (M. Clarke pers. comm.). Seedling recruitment after high-intensity fire (1/1994) at Narrabeen, flowering within 4 months, seedlings observed (P. Kubiak pers. comm.).**Interaction with other organisms:** Used medicinally in Fiji (Cambie & Ash 1994).**Distribution****Status/origin:** Naturalised exotic, native to Africa and Madagascar.**Botanical subregions:** NC CC NT; Qld.**Distribution Sydney area:** Coast and coastal suburbs.**Select locations:** Gordon & Warriewood (M. Clarke pers. comm.), Narrabeen (DHB), Clifton Gardens, Mosman (1966), Parsley Bay, Bellevue Hill, Otford.**Habitat****Habitat:** Weed of disturbed sites.**Altitude:** 0–100 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Occasional.**Vegetation:** Eucalypt woodland.**Substrate:** Sandy soils, moderate nutrients.**Exposure:** Full sun to medium shade.**Conservation****Conservation:** Weed status unknown.***Crepis capillaris* ***

ASTERACEAE

Smooth Hawksbeard

Life history**Growth form:** Herb to 75 cm high, basal leaves usually a rosette.**Vegetative spread:** No.**Longevity:** 1–3 years.**Primary juvenile period:****Flowers:** Yellow, November–April. Insect-pollinated (Ciba-Geigy 1968–).**Fruit/seed:** Achene 2 mm long, with pappus of hairs 8 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed (Carr et al. 1992), also dispersed by wind, water and people; moderate user or nitrogen and competitor for space (Ciba-Geigy 1968–).**Fire response:****Interaction with other organisms:** Palatable to rabbits (Leigh et al. 1987).**Distribution****Status/origin:** Naturalised exotic, native to Europe.**Botanical subregions:** NC CC NT CT ST; Tas.**Distribution Sydney area:** Coast but mainly Tablelands.**Select locations:** Hurstville, Cambewarra, Nowra, Kurrajong Heights, Lithgow, Bathurst, Blayney (1899), Orange, Wombeyan Caves, Robertson.**Habitat****Habitat:** Roadsides and disturbed areas.**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Occasional–frequent.**Vegetation:** Grassy slopes and banks.**Substrate:** Gravelly soils, from limestone, basalt, shale, fertile.**Exposure:****Conservation****Conservation:** Weed status unknown.

***Crepis foetida* subsp. *vulgare* ***

ASTERACEAE

Stinking Hawksbeard

Life history**Growth form:** Herb 10–50 cm high, basal leaves usually a rosette.**Vegetative spread:** No.**Longevity:** 1–2 years.**Primary juvenile period:****Flowers:** Yellow, summer.**Fruit/seed:** Achene 12–17 mm long, pappus of hairs 5–7 mm long, mature June.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe.**Botanical subregions:** CC ST CWS SWS; Vic., Tas.**Distribution Sydney area:** Penshurst.**Select locations:** Penshurst (1906) only record.**Habitat****Habitat:** Roadsides and disturbed areas.**Altitude:** 200 m**Annual rainfall:** 1200 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Rare, Sydney is northern limit.***Crepis setosa* ***

ASTERACEAE

Life history**Growth form:** Herb to 80 cm high, basal leaves usually a rosette.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Yellow, February.**Fruit/seed:** Achene 3–5 mm long, with pappus of hairs 4–5 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind and water-dispersed (Ciba-Geigy 1968–).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe.**Botanical subregions:** CC; Vic., Tas.**Distribution Sydney area:** Hornsby.**Select locations:** Hornsby (1918) only record for NSW.**Habitat****Habitat:** Recorded along laneway.**Altitude:** 100 m**Annual rainfall:** 1200 mm**Typical local abundance:** Rare.**Vegetation:****Substrate:** Soil rich in nutrients, moderately dry (Ciba-Geigy 1968–).**Exposure:****Conservation****Conservation:** Probably now extinct.

Cymbonotus lawsonianus (Arctotis australiensis)

ASTERACEAE

Bears-ear

Life history**Growth form:** Stemless herb to 25 cm diameter.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Yellow, August–October, March–May.**Fruit/seed:** Achene 2.5 mm long, no pappus, mature September–October.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., S.A.**Distribution Sydney area:** Western Sydney, western Blue Mountains to Orange.**Select locations:** Scheyville, St Marys, Narellan, Yerranderie, Hartley, Jenolan Caves, Winburndale, Orange, Abercrombie Caves, Moss Vale.**Habitat****Habitat:** Short grassland.**Altitude:** 0–1000 m**Annual rainfall:** 700–1000 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Eucalypt woodland with grassy ground cover, e.g. with *Eucalyptus moluccana*, *E. crebra*, *E. melliodora*, *E. macroryncha*.**Substrate:** Clay and sandy loams from shales, metamorphics, basalt, fertile, watertable permanently low.**Exposure:** Probably full sun.**Conservation****Conservation:** Presumed extinct in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.***Cymbonotus preissianus*** (*Cymbonotus lawsonianus misappl.*)

ASTERACEAE

Life history**Growth form:** Stemless herb to 25 cm diameter.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Yellow, August–March.**Fruit/seed:** Achene 3–3.5 mm long, no pappus.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CT ST CWS SWS SWP; Vic., S.A., W.A.**Distribution Sydney area:** Jenolan/Abercrombie, Orange.**Select locations:** Oberon, Jenolan SF, Little River, Abercrombie Caves, Mt Werong, Mullion Range.**Habitat****Habitat:** Grassy ground cover.**Altitude:** above 800 m**Annual rainfall:** above 900 mm**Typical local abundance:** Frequent–rare.**Vegetation:** Woodland or forest with grassy or open groundcover, e.g. with *Eucalyptus radiata*, *E. goniocalyx*.

Substrate: Basalt, granite, metamorphics, fertile soil, well-drained, recorded from scraped trail margin.

Exposure:

Conservation

Conservation: Conservation status unknown.

Cynara scolymus *

ASTERACEAE

Globe Artichoke

Life history

Growth form: Herb to 2 m high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Purplish-blue, December.

Fruit/seed: Achene 6 mm long, with pappus of hairs 3–4 cm long.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response:

Interaction with other organisms: Cultivated, young flower heads used as a vegetable.

Distribution

Status/origin: Naturalised exotic, native to Europe, introduced as vegetable plant.

Botanical subregions: CC CT CWS SWP; W.A.

Distribution Sydney area: Sporadic.

Select locations: Catherine Hill Bay (1921), Minto, Bathurst Cemetery.

Habitat

Habitat: Earthworks, disturbed sites.

Altitude: 0–1000 m

Annual rainfall: above 800 mm

Typical local abundance: Rare.

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Naturalised sporadically, not invasive.

Delairea odorata * (Senecio mikanioides)

ASTERACEAE

Cape Ivy

Life history

Growth form: Climbing or scrambling plant with stems many metres long.

Vegetative spread: Stoloniferous.

Longevity: Perennial.

Primary juvenile period: Probably less than 1 year (Lawrence 1985).

Flowers: Yellow, May–August. Probably bee-pollinated, self-incompatible (Lawrence 1985).

Fruit/seed: Achene 2 mm long, with pappus 5 mm long, not persistent, mature July, August. Potential seed set/plant 20 000–40 000 (Lawrence 1985).

Dispersal, establishment & growth: Diaspore: stem fragments, dispersed by gravity or water (Anon 1991). Effectiveness of seed dispersal not known.

Fire response: Usually fails to burn (R. Buchanan pers. comm.). Probably killed by high-intensity fire (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to S Africa, introduced as garden plant.

Botanical subregions: NC CC SC CT; Vic., Tas., S.A.

Distribution Sydney area: Mainly coastal.

Select locations: Hornsby, Narrabeen, Middle Harbour Creek (L.McD.), Woolloomooloo (1902), Stanwell Park, Shellharbour 1906, Albion Park, Minnamurra, Liverpool, Douglas Park, Kangaloon.

	Habitat
Habitat: Weed in moist gullies, roadsides, riverbanks.	
Altitude: 0–700 m Annual rainfall: above 1000 mm	
Typical local abundance: Frequent–occasional.	
Vegetation: Climbs on small trees or over shrubs forming dense ground cover. Moist eucalypt forest, e.g. with <i>Eucalyptus saligna</i> , <i>Syncarpia glomulifera</i> .	
Substrate: Soils from shale, alluvium, and possibly basalt, medium to high nutrient. Requires moisture (M. Clarke pers. comm.).	
Exposure: Sheltered, shady site.	
	Conservation
Conservation: Reported as major weed, carpeting the ground and covering shrubs on Gooseberry Island (Lake Illawarra) in 1891, first reported there in 1857 — recommended control was to use goats (note with Herbarium specimen). Now a widespread and significant bushland weed, though not frequent, e.g. restricted by limited distribution of moist eucalypt forest (R. Buchanan pers. comm.).	

Dimorphotheca pluvialis *

ASTERACEAE

Cape Marigold

Life history

Growth form: Herb to 20 cm high.
Vegetative spread:
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow and purplish, August–November.
Fruit/seed: Achene 6–8 mm long, with broad wing, no pappus.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to South Africa, introduced as ornamental.

Botanical subregions: CC NWS; S.A.

Distribution Sydney area: Coastal headlands in Sydney suburbs.

Select locations: Bangally Head, Sth Bungan Head, Bronte/Tamarama Headland (1976).

Habitat

Habitat: Coastal headlands.
Altitude: 0–1000 m **Annual rainfall:** above 1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Grassy shrubland with *Gazania*, *Westringia*, *Chrysanthemoides*.
Substrate: Sandstone cliffs, probably with clay soil influence.
Exposure:

Conservation

Conservation: Locally naturalised from nearby gardens.

Dittrichia graveolens *

ASTERACEAE

Stinkwort

Life history

Growth form: Erect, densely-branched herb with characteristic conical shape, 30–60 cm high; stem with glandular hairs that exude sticky, strong-scented oil.
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow, March–April.
Fruit/seed: Achene 2 mm long, pubescent, with pappus of bristles, mature April–June.
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed, reported growing to 1.2 m high after heavy rains at Ingleburn.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Mediterranean region including N Africa.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP;
Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Wahroonga, Duck River (1909), Cabramatta, Five Islands,
Nowra, Clarence (1900), Kowmung River, Hilltop, Carcoar.

Habitat

Habitat: Roadsides, old quarries, saltmarsh.

Altitude: 0–1000 m **Annual rainfall:** above 800 mm

Typical local abundance: Frequent–occasional.

Vegetation: Weedy, disturbed sites.

Substrate: Stony river flats, clay soils, recorded in saltmarsh indicating possible salt tolerance. Recorded on saline sites in western NSW (Semple 1993).

Exposure: Full sun.

Conservation

Conservation: Weed status unknown.

Echinops sphaerocephalus *

ASTERACEAE

Globe Thistle

Life history

Growth form: Erect herb 0.5–2 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White or greyish, summer–autumn.

Fruit/seed: Achene, with partially fused pappus, surrounded by bristles.

Dispersal, establishment & growth: Diaspore: fruit. Possibly animal-dispersed,
e.g. sheep, in wool.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe, Asia.

Botanical subregions: CT CWS.

Distribution Sydney area: Gulgong–Orange.

Select locations: Gulgong (1976), Orange (1976).

Habitat

Habitat: Disturbed sites.

Altitude: 800 m **Annual rainfall:** 1000 mm

Typical local abundance: Rare.

Vegetation:

Substrate: Basalt, fertile soil.

Exposure:

Conservation

Conservation: Recently reported exotic species, status unknown.

Eclipta platyglossa

ASTERACEAE

Twin-heads

Life history

Growth form: Usually prostrate herb to 25 cm high, rooting at the nodes.

Vegetative spread: Limited, rooting from nodes.

Longevity: 2 years.

Primary juvenile period:

Flowers: Yellow, January–April.

Fruit/seed: Achene, c. 3 mm long, pappus minute. Mature January–April.
Dispersal, establishment & growth: Diaspore: fruit, probably water-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT NWS CWS SWS NWP SWP SFWP; all mainland States.

Distribution Sydney area: Coastal and western Sydney.

Select locations: Narrabeen, Manly, Royal NP, Richmond, Doonside, Casula.

Habitat

Habitat: Swamps, creeklines.

Altitude: 0–200 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Swamp woodland, e.g. with *Eucalyptus amplifolia*, *Casuarina glauca*, *Melaleuca styphelioides*.

Substrate: Floodplain alluvium, fertile. Watertable mostly high.

Exposure: Light shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), rare elsewhere.

Enydra fluctuans**ASTERACEAE****Life history**

Growth form: Herb with soft, creeping stems and opposite leaves.

Vegetative spread: Stem-creeping, rooting from nodes.

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellowish, spring–summer.

Fruit/seed: Achene, no pappus.

Dispersal, establishment & growth: Diaspore: fruit.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Coast, Sydney Harbour to Port Hacking

Select locations: Kurnell, Port Hacking.

Habitat

Habitat: Swamps.

Altitude: 0–10 m

Annual rainfall: above 1200 mm

Typical local abundance:

Vegetation: Swamps

Substrate:

Exposure:

Conservation

Conservation: Port Hacking is the southern limit. Rare, status unknown.

Epaltes australis* (Sphaeromorpha australis)*ASTERACEAE**

Spreading Nut-heads

Life history

Growth form: Herb 3–25 cm high.

Vegetative spread:

Longevity: Probably short-lived.

Primary juvenile period:

Flowers: Yellowish, September–April.

Fruit/seed: Achene 1–1.5 mm long, with membranous pappus, mature September–April.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT NWP SWP NFWP SFWP; all mainland States.

Distribution Sydney area: Coast and western Sydney.

Select locations: Roseville, Manly, Revesby, Fairfield, Richmond, St Marys, Warrimoo, Appin, Wattamolla, Albion Park.

Habitat

Habitat: Margins of swampy areas.

Altitude: 0–300 mm

Annual rainfall: above 700 mm

Typical local abundance: Frequent.

Vegetation: Swamp vegetation.

Substrate: Sandy to clay soils, watertable periodically high, sometimes brackish.

Exposure: Full sun to light shade.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991), but status elsewhere unknown.

Erechtites valerianifolia *

ASTERACEAE

Brazilian Fireweed

Life history

Growth form: Erect herb 1–1.5 m high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: White–mauve, June–November.

Fruit/seed: Achene 2.5–3.5 mm long, with pappus of numerous hairs.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response: Probably killed, one plant flowering and fruiting within 30 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to S America.

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Coastal, mainly Gosford–Wyong.

Select locations: Dora Creek, Avoca, Peats Ridge, Woy Woy (1929), Red Cedar Flat (Royal NP 1984).

Habitat

Habitat: Weed of fertile soils.

Altitude: 0–100 m

Annual rainfall: above 1200 mm

Typical local abundance:

Vegetation:

Substrate: Fertile soils.

Exposure:

Conservation

Conservation: Mainly confined north of Gosford but recent collection (1984) from Royal NP suggests species is spreading. Common name suggests potential to spread after fire.

***Erigeron karvinskianus* ***

ASTERACEAE

Bony-tip Fleabane

Life history**Growth form:** Sprawling herb 20–30 cm high.**Vegetative spread:** From prostrate stems (R. Buchanan pers. comm.).**Longevity:** Indefinite.**Primary juvenile period:****Flowers:** Pale purple turning white then pink. Flowers at any time of year (R. Buchanan pers. comm.).**Fruit/seed:** Achene, flattened, 1 mm long with pappus of fine whitish hairs 2 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed, water-dispersed (M. Clarke pers. comm.).**Fire response:** Resprouted and flowered within 11 weeks, releasing seeds within 26 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.). Resprouts after low-moderate intensity fires, germinates after any fire (R. Buchanan pers. comm.).**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to America. Introduced as garden ornamental occasionally escaping from gardens and rockeries (Harden 1992).**Botanical subregions:** NC CC CT NWS; Vic., S.A., W.A.**Distribution Sydney area:** Widespread but near habitation.**Select locations:** Avoca, Cheltenham, Lindfield (1960), Pymble, Foxground (1944), Leura, Katoomba, Blackheath.**Habitat****Habitat:** Watercourses, stormwater drains, slopes, path edges.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Moist eucalypt forest, disturbed watercourses.**Substrate:** Sandy soils, fertile–infertile. Damp sandstone rocks, garden rock walls, stormwater outlets (R. Buchanan & M. Clarke pers. comm.).**Exposure:** Mid shade–full sun (R. Buchanan pers. comm.).**Conservation****Conservation:** Potential to invade bush along disturbed creeks, e.g. Katoomba area.***Euchiton gymnocephalus* (Gnaphalium gymnocephalum)**

ASTERACEAE

Creeping Cudweed

Life history**Growth form:** Herb 10–35 cm high.**Vegetative spread:** Spreads by stolons.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** October–April.**Fruit/seed:** Achene 0.7 mm long with pappus of non-persistent bristles 3 mm long, mature December–April.**Dispersal, establishment & growth:** Diaspore: fruit. Coloniser.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC NT CT ST NWS CWS SWS; Vic., Tas., W.A.**Distribution Sydney area:** Widespread.**Select locations:** Culoul Range, Ourimbah, Bayview, Wahroonga, Royal NP, Dapto, Razorback, Jenolan Caves, Mullion Range.**Habitat****Habitat:** Eucalypt open-forest.**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Occasional

Vegetation: Eucalypt open-forest, e.g. *Eucalyptus deanei*, *E. dives*, *E. eugenioides*, occasionally in dry rainforest margins.

Substrate: Sandy to clay loam from shale, granite, metasediments, infertile–fertile.

Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), status elsewhere unknown.

Euchiton involucratus (Gnaphalium involucratum)

ASTERACEAE

Star Cudweed

Life history

Growth form: Woolly, stoloniferous herb 12–50 cm high.

Vegetative spread: Spreads by stolons.

Longevity: Annual or biennial (Purdie 1977).

Primary juvenile period: 1–2 years.

Flowers: At any time of year.

Fruit/seed: Achene 0.6 mm long, mature December–February.

Dispersal, establishment & growth: Diaspore: fruit. Coloniser.

Fire response: Seedlings recorded less than 1 year after fire (Purdie 1977).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC NT CT ST NWS CWS SWS; Qld, Vic., Tas., S.A.

Distribution Sydney area: Coast and montane areas.

Select locations: Martinsville, Carlingford, Beecroft, Bundeena, Orange, Wingecarribee Swamp.

Habitat

Habitat: Creeks, roadsides, pasture, swamps.

Altitude: 0–1000 m **Annual rainfall:** above 1000 mm

Typical local abundance: Frequent.

Vegetation: Moist woodland, sedgeland, grassland, alluvial or peaty soils, fertile–infertile, watertable mostly high.

Substrate: Alluvial or fibrous peaty soils, fertile–infertile. Watertable mostly high.

Exposure:

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991), status elsewhere unknown.

Euryops chrysanthemoides * (Gamolepis chrysanthemoides)

ASTERACEAE

Life history

Growth form: Shrub 0.5–1.5 m high.

Vegetative spread:

Longevity: Indefinite.

Primary juvenile period:

Flowers: Yellow, June.

Fruit/seed: Achene 0.5 mm long, no pappus.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to S Africa.

Botanical subregions: CC.

Distribution Sydney area: Northbridge to Wollongong (Harden 1992).

Select locations: (no specimens)

		Habitat
Habitat: Weed of roadsides.		
Altitude: 0–200 mm	Annual rainfall: above 1200 mm	
Typical local abundance:		
Vegetation: Roadside weeds.		
Substrate:		
Exposure:		
		Conservation
Conservation: Weed status unknown.		

Facelis retusa *

ASTERACEAE

		Life history
Growth form: Herb, 5–30 cm high, with decumbent stems.		
Vegetative spread:		
Longevity: Perennial.		
Primary juvenile period:		
Flowers: White, purple-tipped, October–January.		
Fruit/seed: Achene 1–1.5 mm long, with pappus of numerous papillary hairs.		
Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.		
Fire response:		
Interaction with other organisms:		
		Distribution
Status/origin: Naturalised exotic, native to S America.		
Botanical subregions: NC CC SC CWS.		
Distribution Sydney area: Suburban area and Albion Park.		
Select locations: Cheltenham, Northbridge, Wentworthville, Leumeah, Albion Park (1948).		
		Habitat
Habitat: Weed near habitation: gardens, paths, paddocks.		
Altitude: 0–100 m	Annual rainfall: above 800 mm	
Typical local abundance: Frequent–occasional.		
Vegetation: Wasteland weeds.		
Substrate: Sandy, well-drained soils, fertile.		
Exposure:		
		Conservation
Conservation: Garden weed, probably not invasive of bushland, though probably actively spreading.		

Galinsoga parviflora *

ASTERACEAE

Potato Weed

		Life history
Growth form: Herb 10–60 cm high, with opposite leaves.		
Vegetative spread: No.		
Longevity: 1 year.		
Primary juvenile period: Flowers 4–6 weeks after germination (Ciba-Geigy 1968–), fruiting within 15 weeks (P. Kubiak pers. comm.).		
Flowers: White, disc yellow, February–August. Self-pollinated (Ciba-Geigy 1968–).		
Fruit/seed: Achene 2 mm long, with pappus of short bristles. Fruits ripen on pulled out plants (Ciba-Geigy 1968–).		
Dispersal, establishment & growth: Diaspore: fruit. Dispersed by wind, water, animals and people; germinates in light; vigorous user of nitrogen and competitor for space; sensitive to frost; 2–3 generations per year in favourable conditions (Ciba-Geigy 1968–).		
Fire response: Killed (M. Clarke pers. comm.). Flowered within 12 weeks, and fruiting within 15 weeks of high-intensity fire (1/1994) at Lane Cove, seedlings observed (P. Kubiak pers. comm.).		
Interaction with other organisms: Cattle and sheep especially like this herb (Ciba-Geigy 1968–).		

Distribution

Status/origin: Naturalised exotic, native to S America.

Botanical subregions: NC CC SC NT CT NWS; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Waitara, Dural, Lane Cove, Pennant Hills (M. Clarke pers. comm.). Port Jackson (1850), Como (1887), Richmond, Heathcote, Wollongong, Albion Park, Mt Irvine, Mt Wilson.

Habitat

Habitat: Disturbed habitats and agricultural areas.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Moist eucalypt forests, mangrove edges, disturbed watercourses (M. Clarke pers. comm.).

Substrate: Fertile soil on sandstone, shale. Nitrogenous soil (Ciba-Geigy 1968–).

Exposure: Full sun–semi-shade (M. Clarke pers. comm.).

Conservation

Conservation: Weed of disturbed sites, minor invader of bush. Often confused with *Bidens pilosa* or *Sigesbeckia orientalis* (M. Clarke pers. comm.).

Gazania rigens* **ASTERACEAE****Life history**

Growth form: Herb with decumbent stems forming mats.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Bright orange–deep yellow, most of the year.

Fruit/seed: Achene 4 mm long, covered by hairs.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed, probably also water-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to S Africa. Introduced as garden ornamental, occasionally escaping.

Botanical subregions: CC; S.A.

Distribution Sydney area: Coastal headlands and beaches.

Select locations: Pearl Beach (1973), Palm Beach (1972), Bangally Head, Bronte/Tamarama Headland.

Habitat

Habitat: Coastal sand dunes and roadsides.

Altitude: 0–50 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Coastal herbland, e.g. with *Carpobrotus*, *Lampranthus*, *Westringia*.

Substrate: Beach sand and sandstone cliffs.

Exposure: Full sun.

Conservation

Conservation: Localised garden escape though relatively recent collections (since 1972) possibly indicate increasing spread.

Glossogyne tannensis* (Glossogyne tenuifolia)*ASTERACEAE**

Cobbler's Tack

Life history

Growth form: Herb with erect stems to 60 cm.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, December–April.

Fruit/seed: Achene 7–8 mm long, pappus with barbed awns 1–2 mm long, mature December–April.

Dispersal, establishment & growth: Diaspore: fruit, probably animal-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT NWS CWS NWP NFWP; all mainland States, Pac., Asia, India.

Distribution Sydney area: Western Sydney, Capertee and Shoalhaven Valleys.

Select locations: Ryde, Glenfield, Ingleburn, Doonside, Capertee Valley, Shoalhaven Gorge.

Habitat

Habitat: Drier grasslands and woodlands.

Altitude: 0–600 m

Annual rainfall: 700–1000 mm

Typical local abundance: Frequent–occasional.

Vegetation: Grassland and woodland, e.g. with *Eucalyptus moluccana* and *E. fibrosa*.

Substrate: Clay soils of moderate fertility, from shales, quartzite, slates.

Exposure: Probably full sun.

Conservation

Conservation: Rare and vulnerable in Western Sydney (Benson & McDougall 1991), though elsewhere in NSW reported to be 'common and abundant in large areas if there has been a high summer rainfall' (Harden 1992).

Gnaphalium americanum *

ASTERACEAE

Life history

Growth form: Slender herb 10–35 cm high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Cream–white, mainly October–January.

Fruit/seed: Achene 0.5 mm high, with pappus of bristles 2 mm long.

Dispersal, establishment & growth: Diaspore: fruit, possibly animal-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic of relatively recent origin, native to Central and S America.

Botanical subregions: NC CC SC CT ST; LHI.

Distribution Sydney area: Mainly coastal.

Select locations: Royal Botanic Gardens, Silverwater (1964), Leuhmeah (1964), Werong Beach, Hartley, Burrawang.

Habitat

Habitat: Disturbed areas, tracks, vacant land.

Altitude: 0–700 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent.

Vegetation: With grasses and herbs.

Substrate: Sandy to stony clay soils.

Exposure: Probably full sun.

Conservation

Conservation: Weed of disturbed sites, probably still expanding range.

***Gnaphalium calviceps* ***

ASTERACEAE

Life history**Growth form:** Herb 10–20 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Brown, mainly October–December.**Fruit/seed:** Achene 0.4–0.6 mm long, with a pappus of bristles 2 mm long, mature October–February.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to S America.**Botanical subregions:** NC CC SC NT ST NWS; Vic., Tas., S.A.**Distribution Sydney area:** Sydney, Cumberland Plain and Bathurst.**Select locations:** Royal Botanic Gardens (1902), Little Bay, Cabarita, Castle Hill, Glenfield, Norton's Basin, Mt Annan, Thirlmere, Bathurst.**Habitat****Habitat:** Disturbed sites including sheep pens.**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Occasional.**Vegetation:** Grassland or open woodland, e.g. with *Eucalyptus blakelyi*.**Substrate:** Clay soils, fertile.**Exposure:****Conservation****Conservation:** Weed of disturbed sites, not invasive of bushland.***Gnaphalium coarctatum***

ASTERACEAE

Purplish Cudweed

Life history**Growth form:** Herb 7–40 cm high.**Vegetative spread:** No.**Longevity:** 1–2 years.**Primary juvenile period:****Flowers:** October–April.**Fruit/seed:** Achene, 0.7 mm long, mature November–December.**Dispersal, establishment & growth:** Diaspore: fruit, wind- and possibly animal-dispersed (Carr et al. 1992).**Fire response:** Probably killed; fruiting within 25 weeks, seeds shed within 27 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).**Interaction with other organisms:** Leaves, seed, and stems eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).**Distribution****Status/origin:** Naturalised exotic, native to America.**Botanical subregions:** NC CC SC NT NWS CWS SWS; LHI, Qld, Vic.**Distribution Sydney area:** Mainly coast.**Select locations:** Narara, Point Claire (1931), Pennant Hills, Narrabeen, Manly, Granville, Lower Portland, Castle Hill.**Habitat****Habitat:** Disturbed ground, footpaths, parks, cleared areas.**Altitude:** 0–100 m**Annual rainfall:** above 750 mm**Typical local abundance:** Occasional–frequent.**Vegetation:** Lawns, grassland and with weeds of disturbed sites, e.g. *Bidens pilosa*, *Plantago lanceolata*.**Substrate:** Mainly clay soils, fertile, cracks in pavements.**Exposure:** Full sun.**Conservation****Conservation:** Weed of disturbed sites, not likely to be invasive of bushland.

Gnaphalium pensylvanicum *

ASTERACEAE

Life history

Growth form: Erect to procumbent woolly herb 20–50 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** White, September–October.**Fruit/seed:** Achene 0.5 mm long, with pappus of non-persistent bristles 2 mm long, mature July–December.**Dispersal, establishment & growth:** Diaspore: fruit.**Fire response:** Probably killed; flowering and fruiting within 15 weeks of high-intensity fire at Lane Cove, seedlings observed (P. Kubiak pers. comm.).**Interaction with other organisms:**

Distribution

Status/origin: Naturalised exotic, native to America and introduced by 1805.**Botanical subregions:** NC CC SC; LHI, Qld.**Distribution Sydney area:** Sydney suburbs.**Select locations:** Ettalong, Harbord, Carlingford, Lane Cove, Port Jackson (1805), Centennial Park, Sans Souci, Ingleburn, Castle Hill, Richmond.

Habitat

Habitat: Disturbed sites, garden and lawn weed, along tracks.**Altitude:** 0–100 m**Annual rainfall:** above 700 mm**Typical local abundance:** Occasional.**Vegetation:** Weeds of disturbed sites.**Substrate:** Sandy soil, infertile.**Exposure:** Full sun.

Conservation

Conservation: Long established weed of disturbed sites, unlikely to invade bushland.*Gnaphalium polycaulon*

ASTERACEAE

Life history

Growth form: Erect to ascending herb to 15 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** July–December.**Fruit/seed:** Achene 0.5 mm long, with pappus of barbed bristles 2 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, probably animal-dispersed.**Fire response:** Probably killed.**Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** CT NWP SWP; Qld, Vic., W.A.**Distribution Sydney area:** Newnes Plateau.**Select locations:** Newnes Glowworm tunnel (only record for area).

Habitat

Habitat: Along road verge though reported along watercourses further west.**Altitude:** 1000 m**Annual rainfall:** 1200 mm**Typical local abundance:** Occasional.**Vegetation:** Heath–scrub.**Substrate:** Sandy podsolic soil on sandstone.**Exposure:**

Conservation

Conservation: Mainly a western species, Newnes is eastern limit. Conservation status unknown.

Gnaphalium sphaericum

ASTERACEAE

Life history**Growth form:** Erect herb 5–50 cm high, rarely biennial.**Vegetative spread:** No.**Longevity:** 1–2 years.**Primary juvenile period:** Less than 1 year.**Flowers:** At any time of year.**Fruit/seed:** Achene 0.7 mm long with pappus of non-persistent bristles 2 mm long, matures at any time of year.**Dispersal, establishment & growth:** Diaspore: fruit. Coloniser.**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP;

Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread.**Select locations:** Culoul range, Windsor, Castle Hill, Wahroonga, Minto, Bulli Pass, Albion Park, Berry, Mt Bindo, Boyd Plateau.**Habitat****Habitat:** Disturbed sites, roadsides, bare ground, ridge-top, slopes, creek bank.**Altitude:** 0–1100 m**Annual rainfall:** above 700 mm**Typical local abundance:** Occasional–common.**Vegetation:** Eucalypt woodland and grassland, e.g. with *Eucalyptus deanei*, *E. tereticornis*, *E. fibrosa*, *E. pauciflora*, *E. dalrympleana*, *E. dives*.**Substrate:** Various soils from shale, volcanics, slate, metasediment, rare on sandstone.**Exposure:** Mid shade–full sun.**Conservation****Conservation:** Conserved in Western Sydney (Benson & McDougall 1991), status elsewhere unknown.***Grindelia camporum* var. *australis* ***

ASTERACEAE

Life history**Growth form:** Herb with woody crown growing 0.5–1.2 m high.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** Yellow, summer–autumn. January–May.**Fruit/seed:** Achene 2–3.5 mm long, with pappus of several smooth awns.**Dispersal, establishment & growth:** Diaspore: fruit.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to N America. Occasionally naturalised.**Botanical subregions:** CT.**Distribution Sydney area:** Bathurst–Orange.**Select locations:** Bathurst–Orange (1932), Bathurst (1944).**Habitat****Habitat:** Pasture and stream banks.**Altitude:** 700–1000 m**Annual rainfall:** 600–900 mm**Typical local abundance:****Vegetation:** Ground stratum, pasture and stream banks.**Substrate:****Exposure:****Conservation****Conservation:** Occasionally naturalised.

***Guizotia abyssinica* ***

ASTERACEAE

Rantil, Niger Seed

Life history**Growth form:** Herb to 2 m high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Yellow, April–June.**Fruit/seed:** Achene 4 mm long, no pappus.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Ethiopia. Cultivated in Africa and India for oil.

The few collections have resulted from imported bird seed (Harden 1992).

Botanical subregions: NC CC; Qld.**Distribution Sydney area:** Sydney suburbs.**Select locations:** Eastwood, Earlwood, Kellyville (1974).**Habitat****Habitat:** Gardens.**Altitude:** 0–100 m**Annual rainfall:** above 1000 mm.**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Uncommon weed.***Gymnocoronis spilanthoides* ***

ASTERACEAE

Temple Plant, Senegal Tea

Life history**Growth form:** Rhizomatous herb 1–2.5 m high; stems ribbed, hollow and cane-like.**Vegetative spread:** Spreading by rhizome.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** White, February.**Fruit/seed:** Achene 0.5 mm long, no pappus.**Dispersal, establishment & growth:** Diaspore: fruit, also regrows from stem nodes. Re-grew from plants raked from dam and sprayed with herbicide (Herbarium note 1985).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to S America.**Botanical subregions:** NC CC.**Distribution Sydney area:** Sydney, Illawarra.**Select locations:** Duck River (Auburn) (1991), Dapto (1985), Fairy Meadow (1985).**Habitat****Habitat:** Riverbanks and in still to slow-flowing waters in dams, drains and creeks.**Altitude:** 0–100 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Dominant–frequent.**Vegetation:** Wetland.**Substrate:** Riverbank alluvium. Soil fertile. Watertable permanently high, moisture supply continuous, fresh; grows from bank into water 1 m deep (Herbarium note 1985).**Exposure:** No shade.**Conservation****Conservation:** A declared noxious weed in NSW. Probably spreading.

***Hedynois rhagadioloides* subsp. *cretica* ***

ASTERACEAE

Cretan Weed

Life history

Growth form: Annual 3–50 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, August–November.

Fruit/seed: Achene 5–7 mm long, with pappus 3–6 mm long, barbed.

Dispersal, establishment & growth: Diaspore: fruit, possibly animal-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Mediterranean region.

Botanical subregions: CC NT NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Western Sydney.

Select locations: Hornsby, Homebush (1909), Flemington Saleyards, Bringelly, Menangle, Camden, Albion Park.

Habitat

Habitat: Weed of pastures and disturbed sites.

Altitude: 0–200 m

Annual rainfall: 700–1200 mm

Typical local abundance: Rare.

Vegetation: Grassland.

Substrate: Clay soil from shale, fertile. Recorded on saline sites in western NSW (Semple 1993).

Exposure:

Conservation

Conservation: Minor weed of pastures, not invasive of bushland.

***Helianthus annuus* ***

ASTERACEAE

Common Sunflower

Life history

Growth form: Herb with taproot, 1–2 m high.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period: 3 months.

Flowers: Bright yellow, throughout the year.

Fruit/seed: Achene, 5–10 mm long, no pappus.

Dispersal, establishment & growth: Diaspore: fruit, dispersed by humans.

Fire response: Flowering within 12–13 weeks of high-intensity fire 1/1994 at Lane Cove and Narrabeen, possibly growing from seed introduced to feed wildlife (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N America. Widely cultivated for the oil extracted from the seeds, and sometimes grown as an ornamental. Cultivated forms have larger heads than naturalised plants.

Botanical subregions: NC CC ST NWS CWS NWP SWP NFWP SFWP; all mainland States.

Distribution Sydney area: Narellan.

Select locations: Narellan Rubbish tip (1968) only record.

Habitat

Habitat: Roadsides and disturbed sites.

Altitude: 0–300 m

Annual rainfall: above 700 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure: Full sun.

Conservation

Conservation: Probably established from split grain and unlikely to persist. Unlikely to be naturalised in Sydney area.

***Helianthus tuberosus* ***

ASTERACEAE

Jerusalem Artichoke

Life history**Growth form:** Erect herb with short rhizomes and tubers, 1.5–3 m high.**Vegetative spread:** Tubers.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** Yellow, summer.**Fruit/seed:** Achene, 4–6 mm long, with pappus of scales.**Dispersal, establishment & growth:** Diaspore: fruit, tubers, dispersed by humans.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native of North and S America. Frequently cultivated for its edible tubers. Rare garden escape probably as a result of dumping tubers.**Botanical subregions:** CC CWS SWP; W.A.**Distribution Sydney area:** Sydney suburbs.**Select locations:** Northbridge (1965), Campbelltown (1971).**Habitat****Habitat:** Roadsides and in wasteland near habitation (Harden 1992).**Altitude:** 0–300 m**Annual rainfall:** above 700 mm**Typical local abundance:****Vegetation:****Substrate:** Clay soil.**Exposure:****Conservation****Conservation:** Minor weed, rare in Sydney area.***Helichrysum adenophorum* var. *waddelliae***

ASTERACEAE

Life history**Growth form:** Herb 20–50 cm high, grows in clumps.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** White–pink, September–March.**Fruit/seed:** Achene with pappus of barbed bristles, mature April.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed, possibly colonising disturbed soil.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC CT ST; Vic, S.A.**Distribution Sydney area:** Newnes, Putty area, Paddys River.**Select locations:** Howes Valley, Putty, Clarence, Lithgow, Paddys River.**Habitat****Habitat:** Hillsides, ridgetops.**Altitude:** 0–1100 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Eucalypt forest.**Substrate:** Sand and sandy soil on sandstone, infertile, well-drained.**Exposure:****Conservation****Conservation:** Conservation status unknown.

Helichrysum calvertianum

ASTERACEAE

Life history

Growth form: Twiggy subshrub to 30 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, often tinged pink, January–July.
Fruit/seed: Achene with pappus of bristles.
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Restricted to Fitzroy Falls, Berrima and Mittagong.
Select locations: Mittagong, Berrima, Joadja, Fitzroy Falls, Barbers Creek.

Habitat

Habitat: Eucalypt woodland.
Altitude: 800–1000 m **Annual rainfall:** above 900 mm
Typical local abundance:
Vegetation: Dry eucalypt woodland.
Substrate: Sandy soil.
Exposure:

Conservation

Conservation: Local endemic species, uncommon, conservation status unknown.

Helichrysum collinum

ASTERACEAE

Life history

Growth form: Robust, woody herb to 1 m high, grey–white woolly.
Vegetative spread:
Longevity: Perennial.
Primary juvenile period:
Flowers: Yellow, September–March, peak November.
Fruit/seed: Achene with pappus of bristles, mature October–December.
Dispersal, establishment & growth: Diaspore: fruit.
Fire response: Regrowth only from surviving rootstocks, seedlings recorded less than 1 year after fire (Purdie 1977).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS NWP; Qld.
Distribution Sydney area: Widespread.
Select locations: Wollombi, Como, Macquarie Fields, Glenbrook, Yanderra, Yerranderie, Bomaderry, Kanangra, Hill Top, Mittagong, Wingello.

Habitat

Habitat: Ridges.
Altitude: 0–1000 m **Annual rainfall:** above 800 mm
Typical local abundance: Occasional.
Vegetation: Eucalypt woodland, e.g. with *Angophora bakeri*, *Eucalyptus sieberi*, *E. punctata* with shrubby understorey.
Substrate: Sandy loam from sandstone, also shale, deep, well-drained.
Exposure:

Conservation

Conservation: Not common, conservation status unknown.

Helichrysum elatum

ASTERACEAE

White Paper Daisy

Life history**Growth form:** Woody shrub or subshrub 60–200 cm high.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** White, June–November, peak September.**Fruit/seed:** Achene with pappus of bristles 7 mm long, mature June–January, peak October.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed (Westoby et al. 1990), possible coloniser of disturbed soil.**Fire response:** Possibly killed by high-intensity fire at Narrabeen (P. Kubiak pers. comm.).**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST; Qld, Vic**Distribution Sydney area:** Widespread, localised.**Select locations:** Mt Kindarun, Tuggerah, Gosford, Hornsby, Mt Keira, Thirlmere, Berry, Kangaroo Valley, Mt Wilson, Katoomba, Hill Top, Kangaloon (P. Kodela pers. comm.).**Habitat****Habitat:** Hillsides, valleys.**Altitude:** 0–1000 m**Annual rainfall:** above 900 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** In open to tall open eucalypt forest, e.g. *Eucalyptus fastigata*, *E. cypellocarpa*, *E. obliqua*, *E. globoides* (P. Kodela pers. comm.), also edge of rainforest.**Substrate:** High nutrient soils, disturbed sites, mostly on basalt, shale or on sandy soil from sandstone, conglomerate. On shale, sometimes sandstone, in Kangaloon area (P. Kodela pers. comm.).**Exposure:** Sheltered.**Conservation****Conservation:** Conservation status unknown.***Helichrysum leucopsideum***

ASTERACEAE

Satin Everlasting

Life history**Growth form:** Herb 15–20 cm high, with woody rootstock.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** White, sometimes tinged pink in bud, November–May.**Fruit/seed:** Achene with pappus of barbed bristles, January–April.**Dispersal, establishment & growth:** Diaspore: fruit. Possible coloniser of disturbed ground.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC CT ST NWP SWP SFWP; Vic., Tas., S.A., W.A.**Distribution Sydney area:** Widespread, but mainly upper Blue Mountains, localised.**Select locations:** Kogarah, Cambewarra, Newnes Plateau, Bell, Hassans Walls, Hilltop, Kangaloon, Wingello.**Habitat****Habitat:** Slopes and ridges.**Altitude:** 0–1100 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Eucalypt forest, e.g. with *Pteridium esculentum*, *Lomandra longifolia*, *Eucalyptus rossii*.**Substrate:** Sandy loam.

Exposure: Open areas.

Conservation: Conservation status unknown.

Conservation

Helichrysum rutidolepis

ASTERACEAE

Pale Everlasting

Life history

Growth form: Decumbent, woolly herb 15–40 cm high.

Vegetative spread: Creeping rhizome.

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, December–June, peak March–April.

Fruit/seed: Achene with pappus of bristles, mature March–April.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response: Resprouted, a few plants flowering and fruiting within 18 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST SWS SWP; Vic., S.A.

Distribution Sydney area: Coast and mountains.

Select locations: Eastwood, Lane Cove River, Douglas Park, Euroka, Austinmer, Mt Gibraltar, Kangaroo Valley, Mt Hay, Jenolan Caves, Kanangra.

Habitat

Habitat: Hillsides, rocky gorges.

Altitude: 0–1000 m

Annual rainfall: above 800 mm

Typical local abundance: Occasional.

Vegetation: Wet eucalypt forest and rainforest fringes, e.g. with *Eucalyptus fastigata*, *E. radiata*, *E. stellulata*, *E. punctata*, or grasslands, e.g. with *Stellaria pungens*.

Substrate: Basalt soils, less commonly sandy loam from sandstone, fertile soil.

Exposure:

Conservation

Conservation: Not known.

Helichrysum scorpioides

ASTERACEAE

Button Everlasting

Life history

Growth form: Herb to 30 cm high. An undescribed taxon close to *H. scorpioides* occurs in the Robertson–Mittagong area (P. Kodela pers. comm.).

Vegetative spread: New growth from rhizomes up to 30 cm from old stem, probably with subsequent separation to form new plants. [Can be propagated by severing sucker shoots (Langkamp 1987).]

Longevity: Perennial. Individual plants probably relatively short-lived.

Primary juvenile period:

Flowers: Yellowish, December–June.

Fruit/seed: Achene with barbed hairs. Mature February–June.

Dispersal, establishment & growth: Diaspore: fruit. Wind-dispersed.

Fire response: Resprouted, some plants flowering within 16 weeks and fruiting within 23 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS; Vic., Tas., S.A.

Distribution Sydney area: Widespread.

Select locations: Lane Cove River, Otford, Berry, Kangaroo Valley, Castlereagh, Glenbrook, Mt Wilson, Kanangra Deep, Jenolan Caves, Hilltop, Mt Gibraltar.

		Habitat
Habitat: Disturbed sites, edges of wooded roadsides.		
Altitude: 0–1000 m	Annual rainfall: above 800 mm	
Typical local abundance: Frequent–occasional.		
Vegetation: Open-forest, e.g. with <i>Eucalyptus radiata</i> , <i>E. punctata</i> , <i>E. piperita</i> , <i>E. fastigata</i> , <i>E. viminalis</i> , <i>E. blaxlandii</i> . Woodland, e.g. <i>Eucalyptus sclerophylla</i> – <i>Angophora bakeri</i> .		
Substrate: Variable brown clay from basalt, sandy loam from sandstone, shale–sandstone transition. Soil very fertile–fertile. Watertable mostly low, moisture supply intermittent, fresh, sometimes moist sites, e.g. swamp edge.		
Exposure: Sheltered situations; light shade.		
		Conservation
Conservation: Conserved in Western Sydney (Benson & McDougall 1991). Status elsewhere unknown.		

<i>Helminthotheca echioides</i> * (<i>Picris echioides</i>)	ASTERACEAE
Ox-tongue	
	Life history
Growth form: Herb 30–100 cm high, with taproot.	
Vegetative spread:	
Longevity: 1–2 years.	
Primary juvenile period:	
Flowers: Yellow, October–November.	
Fruit/seed: Achene 3 mm long, with pappus of bristles 5 mm long.	
Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.	
Fire response:	
Interaction with other organisms:	
	Distribution
Status/origin: Naturalised exotic, native to Europe, Asia, Africa.	
Botanical subregions: CC SC CWS SWP; Qld, Vic., Tas., S.A., W.A.	
Distribution Sydney area: Wollongong.	
Select locations: Mt Ousley Road (1967) only record for Sydney area.	
	Habitat

Habitat: Gravel dump.	
Altitude: 0–400 m	Annual rainfall: above 1200 mm
Typical local abundance: Occasional.	
Vegetation:	
Substrate:	
Exposure:	
Conservation: Minor weed, rare in Sydney area, mainly recorded from western NSW.	Conservation

<i>Hemizonia pungens</i> *	ASTERACEAE
Spikeweed	
	Life history
Growth form: Herb; glandular, hairy and aromatic.	
Vegetative spread: No.	
Longevity: 1 year.	
Primary juvenile period: Less than 1 year.	
Flowers: Yellow, summer–autumn.	
Fruit/seed: Achene 1–2 mm long with small apically offset horn.	
Dispersal, establishment & growth:	
Fire response:	
Interaction with other organisms:	
	Distribution
Status/origin: Naturalised exotic, native to N America.	
Botanical subregions: CT ST SWS.	

Distribution Sydney area: Orange.

Select locations: Orange (1923) only record for Sydney area.

Habitat

Habitat: Pasturelands.

Altitude: 800 m

Annual rainfall: 1000 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Uncommon weed in the Orange, Culcairn and Canberra districts.

Hypochaeris glabra *

ASTERACEAE

Smooth Catsear

Life history

Growth form: Herb 10–40 cm high with slender taproot.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, October–December.

Fruit/seed: Achene 3–5 mm long, of two types: inner with pappus of plumose bristles, outer with scabrous bristles, 8–10 mm long. Mature October–December.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response: Seedlings recorded less than 1 year after fire (Purdie 1977).

Interaction with other organisms: Roots eaten by Sulphur-crested Cockatoo *Cacatua galerita* (Lepschi 1993).

Distribution

Status/origin: Naturalised exotic, native to Europe, Asia, Africa.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; LHI, Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Sydney and lower Blue Mountains.

Select locations: Pennant Hills, Port Jackson (1882), Cooks River, Liverpool, Camden, Machins Crater, Bullio.

Habitat

Habitat: Lawns, pastures, woodland and disturbed habitats.

Altitude: 0–800 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent.

Vegetation: Woodland, mown areas.

Substrate: Clay soils and sandy loam from shale, volcanic necks, fertile, well drained.

Exposure:

Conservation

Conservation: Common weed though not invasive of bushland.

Hypochaeris microcephala var. *albiflora* *

ASTERACEAE

White Flatweed

Life history

Growth form: Herb 10–40 cm high, with radical leaves and a fleshy taproot.

Vegetative spread: No.

Longevity: Perennial.

Primary juvenile period:

Flowers: White, October–December.

Fruit/seed: Achene 5 mm long, with pappus of plumose bristles 5–8 mm long, mature October–December.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed, also possibly spread in grain.

Fire response:

Interaction with other organisms:

		Distribution
Status/origin: Naturalised exotic, native to Europe, Asia, Africa.		
Botanical subregions: NC CC NWS NWP; Qld.		
Distribution Sydney area: Sydney and Cumberland Plain		
Select locations: Denistone, Concord (1965), Whalan, Mt Druitt, Camden.		
		Habitat
Habitat: Disturbed native vegetation and lawns, e.g. with <i>Hypochaeris radicata</i> , <i>Taraxicum officinale</i> .		
Altitude: 0–200 m	Annual rainfall: above 700 mm	
Typical local abundance: Occasional–frequent.		
Vegetation: Moist eucalypt forest, lawn.		
Substrate: Clay soil from Wianamatta Shale, fertile. Watertable permanently low.		
Exposure:		
		Conservation
Conservation: Weed of relatively recent introduction. Probably not invasive of bushland.		

Hypochaeris radicata *

ASTERACEAE

Catsear, Flatweed

Life history

Growth form: Herb 15–80 cm high with a basal rosette; growing from hard, thickened overwintering base, fibrous-rooted, but often with several enlarged roots and appearing tap-rooted (Turkington & Aarssen 1983).

Vegetative spread: Only by perennating buds, frequently multi-crowned in lawns; root segments do not regenerate without portion of the crown (Turkington & Aarssen 1983).

Longevity: Several years?

Primary juvenile period: Flowering plants can be produced from seed in 2 months (Turkington & Aarssen 1983).

Flowers: Yellow, at any time with peaks in June and November. Cross-pollinated and self-incompatible; sunlight essential for flower-opening — once open cannot close for at least 3 hours (Turkington & Aarssen 1983).

Fruit/seed: Achene 4–7 mm long, with plumed pappus 8–14 mm long, mature at any time.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed, probably over long distances. Animal-dispersed (Carr et al. 1992). Coloniser of disturbed sites. Usually found as isolated rosettes, or small group probably clonal; light required for germination 33–94% from fresh seed, no dormancy; over-winters as basal rosette; true hemicryptophyte; mowing and grazing appears to stimulate growth of new leaves and favour flowering and fruiting in N.Z. (Turkington & Aarssen 1983). Grazing by snails *Helix aspersa* influences plant size variability (Weiner 1993).

Fire response: Regrows from surviving rootstocks, seedlings recorded less than 1 year after fire (Purdie 1977). Resprouted, flowering and fruiting within 10–13 weeks of high-intensity fire (1/1994) at Lane Cove and Narrabeen (P. Kubiak pers. comm.).

Interaction with other organisms: May have allelopathic effects on other plant species inducing reduced shoot growth rate, also autotoxic (Turkington & Aarssen 1983). Palatable to rabbits (Leigh et al. 1987). Flowers eaten by Galah *Cacatua roseicapilla*, roots eaten by Sulphur-crested Cockatoo *Cacatua galerita*, flowers eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993). (For list of insect predators see Turkington & Aarssen 1983.)

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS SWP NFWP SFWP; LHI, Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Chatswood, Centennial Park, Lady Robinsons Beach (1887), Berry, Parramatta, Elderslie, Medlow Bath, Bathurst, Orange, Wildes Meadow.

Habitat

Habitat: Lawns, gardens, roadsides, pastures, swamp margins, disturbed habitats.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent

Vegetation: Grassland and disturbed forest, but found on swamp margins (P. Kodela pers. comm.).

Substrate: Clay to sandy soils, from shale, basalt, sandstone, coal waste, fertile–infertile. Drought-tolerance related to deep rooting, found on well-drained sites, absent from waterlogged sites, tolerant of nutrient-deficient soils, has some degree of salt-tolerance (Turkington & Aarssen 1983).

Exposure: Full sun.

Conservation

Conservation: Widespread and common weed on edges of disturbed native vegetation and capable of invasion into open grassland areas and along tracks. Neutral to slightly alkaline soil conditions aid invasion of bushland (R. Buchanan pers. comm.).

Isoetopsis graminifolia

ASTERACEAE

Grass Cushion

Life history

Growth form: Herb to 5 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellowish.

Fruit/seed: Achene 2 mm long, with outer hairs and scales, inner achenes aborted.

Dispersal, establishment & growth: Diaspore: fruit.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NT CT ST NWS CWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Winburndale.

Select locations: Winburndale (1977) only Sydney area record.

Habitat

Habitat:

Altitude: 1000 m

Annual rainfall: 1000 mm

Typical local abundance: Rare.

Vegetation: With herbaceous species, e.g. *Helipterum australe*, *Anguillaria*, *Plantago*, *Ophioglossum*.

Substrate: Sandy to loamy red earths.

Exposure:

Conservation

Conservation: Chiefly a western species, rare in Sydney area.

Lactuca saligna *

ASTERACEAE

Willow-leaved Lettuce

Life history

Growth form: Herb 30–100 cm high, with long taproot.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period:

Flowers: Yellow, October–May.

Fruit/seed: Achene 5–9 mm long, with pappus of bristles 3 mm long.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe, Asia, Africa.

Botanical subregions: NC CC NT CT ST NWS CWS SWS SWP; LHI, Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Hornsby, Flemington, Penrith, Mt Wilson (1902), Bathurst.

Habitat

Habitat: Gardens, roadsides, wasteland, cultivation and degraded pastures.

Altitude: 0–1000 m **Annual rainfall:** 700–1300 mm

Typical local abundance:

Vegetation:

Substrate: Clay soils, cultivated sites. Recorded on saline sites in western NSW (Semple 1993).

Exposure:

Conservation

Conservation: Common weed but not invasive of bushland.

Lactuca serriola *

ASTERACEAE

Prickly Lettuce

Life history

Growth form: Erect herb 1–2 m high, with long taproot.

Vegetative spread: No.

Longevity: Less than 2 years.

Primary juvenile period:

Flowers: Yellow, September–April.

Fruit/seed: Achene 6–8 mm long, with pappus of bristles 3 mm long.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response:

Interaction with other organisms: Seed eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).

Distribution

Status/origin: Naturalised exotic, native to Europe, Asia.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Bondi, Gladesville, Richmond, Penrith (1912), Camden, Abercrombie River, Robertson (P. Kodala pers. comm.), Moss Vale.

Habitat

Habitat: Gardens, roadsides, wasteland, cultivation and degraded pastures.

Altitude: 0–800 m **Annual rainfall:** above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Ephemeral weeds.

Substrate: Fertile soils, clay. Recorded on saline sites in western NSW (Semple 1993).

Exposure: Full sun.

Conservation

Conservation: Minor weed.

Lagenifera gracilis

ASTERACEAE

Slender Lagenophora

Life history

Growth form: Herb with short rhizome, roots fleshy.

Vegetative spread: No, rhizome short, vertical.

Longevity:

Primary juvenile period:

Flowers: White–purple, October–April.

Fruit/seed: Achene 2–3.5 mm long, no pappus, mature October–April, peak March.

Dispersal, establishment & growth: Diaspore: fruit.

Fire response: Probably resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT; Qld, Vic., Tas., S.A., Malesia.

Distribution Sydney area: Widespread at lower elevations.

Select locations: Watagans, MacDonald River, Dalrymple Hay NR, Scarborough, Bilpin, Berkshire Park, Kentlyn, Thirlmere, Albion Park, Kangaroo Valley.

Habitat

Habitat: Moist gullies and near water

Altitude: 0–600 m

Annual rainfall: above 700 mm

Typical local abundance: Occasional.

Vegetation: Various — moist open-forest, e.g. with *Eucalyptus saligna*, *Syncarpia glomulifera*, *Allocasuarina torulosa*, *Melaleuca* scrub and sedge moorland. Ground stratum.

Substrate: Sandy loam from shale enriched sandstone, or from shales. Soil fertile–infertile.

Watertable mostly low, moisture supply continuous, fresh, sometimes seepage areas.

Exposure: In sheltered situations, mid–light shade.

Conservation

Conservation: Conservation status unknown.

Lagenifera stipitata

ASTERACEAE

Blue Bottle-daisy, Common Lagenophora

Life history

Growth form: Stoloniferous herb to 40 cm high, roots fibrous.

Vegetative spread: Spreads by stolons.

Longevity: Perennial.

Primary juvenile period:

Flowers: White, pale pink, bluish or mauve to purple, September–April, peak November–December.

Fruit/seed: Achene 2–4 mm long, no pappus, mature November–April.

Dispersal, establishment & growth: Diaspore: fruit, no special dispersal morphology (Westoby et al. 1990).

Fire response: Stems killed, resprouted from ground level and flowered within a month at Mona Vale after high-intensity fire (1/1994) (L.McD.). Resprouted, flowering within 9 weeks and seeds shed within 12 weeks of high-intensity fire at Lane Cove in 1994 (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS; Qld, Vic., Tas., S.A., N.Z.

Distribution Sydney area: Coast and Upper Blue Mountains.

Select locations: Mooney Mooney Creek, Mona Vale (L.McD.), Austinmer, Seven Mile Beach, Culoul Range, Londonderry, Mt Tomah, Mt Cameron, Lithgow, Govetts Leap, Robertson (P. Kodala pers. comm.).

Habitat

Habitat: Moist sheltered sites.

Altitude: 0–1200 m

Annual rainfall: above 1200 mm

Typical local abundance: Occasional.

Vegetation: Moist eucalypt open-forest, e.g. with *Eucalyptus deanei*, *E. cypellocarpa*, *E. fastigata*, *E. viminialis* with grassy understorey. Ground stratum.

Substrate: Basalt, shale, granite, talus, sandy loam. Soil very fertile–fertile. Watertable mostly low, moisture supply intermittent, fresh.

Exposure: In sheltered places, mid–shade–full sun.

Conservation

Conservation: Conservation status unknown.

***Leontodon taraxacoides* subsp. *taraxacoides* ***

ASTERACEAE

Lesser Hawkbit

Life history**Growth form:** Herb 15–40 cm high, with radical leaves.**Vegetative spread:** No.**Longevity:** 2–25 years.**Primary juvenile period:****Flowers:** Yellow, October–April.**Fruit/seed:** Achene 5 mm long, with pappus of plumose bristles, mature October–April.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe. Cultivated at Royal Botanic Gardens in 1951 from seed removed as impurity from linseed apparently grown in Victoria.**Botanical subregions:** NC CC SC NT CT ST SWP; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:** Coast, western Sydney, Southern Highlands.**Select locations:** Pittwater (1962), La Perouse, Yennora, Glenfield (1963), Casula, Doonside, Mt Druitt, Menangle, Camden, Wingecarribee Swamp (P. Kodela pers. comm.).**Habitat****Habitat:** Lawns, wasteland, cemeteries, swamp margins (P. Kodela pers. comm.).**Altitude:** 0–700 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent.**Vegetation:** Weedy areas, grassland, e.g. with *Taraxicum officinale*, *Hyochaeris radicata*.

Pasture/sedgeland ecotone (P. Kodela pers. comm.).

Substrate: Sandy soil, clayey soils from shale, possibly salt-tolerant? Damp swamp margin area (P. Kodela pers. comm.).**Exposure:** Full sun.**Conservation****Conservation:** Recently introduced weed species probably still spreading, but unlikely to invade bushland.***Leptinella longipes* (Cotula longipes)**

ASTERACEAE

Life history**Growth form:** Herb with prostrate branches.**Vegetative spread:** Stoloniferous.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** April.**Fruit/seed:** Achene 1–2.5 mm long, no pappus.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC CT; Qld, Vic., Tas.**Distribution Sydney area:** Mainly coastal.**Select locations:** Woy Woy, Narrabeen, Dee Why, Manly, Botany, Rockdale, Stanwell Park, Mt Kembla, Jenolan Caves (1900).**Habitat****Habitat:** Swamps.**Altitude:** 0–1000 m**Annual rainfall:** above 900 mm**Typical local abundance:****Vegetation:** Swamps, lagoon margins.**Substrate:** Poorly-drained sites, possibly salt-tolerant?**Exposure:****Conservation****Conservation:** Rare, last collected in Sydney area in 1950, (at Dee Why).

Leptorhynchus elongatus**ASTERACEAE****Life history****Growth form:** Herb to 40 cm high, with woody taproot.**Vegetative spread:****Longevity:** Short, perennial.**Primary juvenile period:****Flowers:** White–pale yellow, November.**Fruit/seed:** Achene with pappus of bristles, mature November.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NT CT ST NWS CWS SWS; Vic., Tas., S.A., W.A.**Distribution Sydney area:** Western parts of area.**Select locations:** Jenolan Caves (1899) only Sydney area record.**Habitat****Habitat:****Altitude:** 800 m**Annual rainfall:** 900 mm**Typical local abundance:****Vegetation:** Woodland and grassland.**Substrate:****Exposure:****Conservation****Conservation:** Rare, no recent records for Sydney area.***Leptorhynchus nitidulus*****ASTERACEAE****Life history****Growth form:** Slender, stoloniferous herb to 25 cm high.**Vegetative spread:** Stoloniferous.**Longevity:****Primary juvenile period:****Flowers:** Yellow, summer–autumn.**Fruit/seed:** Achene with pappus of bristles.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC CT; Vic., Tas.**Distribution Sydney area:** Hurstville–Yennora, Bathurst.**Select locations:** Hurstville (1895), Auburn (1888), Yennora (1965), Bathurst (19th century).**Habitat****Habitat:** Forests, clearings and roadsides.**Altitude:** 0–800 m**Annual rainfall:** above 1000 mm**Typical local abundance:****Vegetation:** Woodland with shrubby understorey, e.g. *Callistemon pinifolius*, *Chorizema parvifolium*, *Pultenaea pedunculata*, sometimes swampy areas.**Substrate:** Sandy clay soil from Wianamatta Shale.**Exposure:****Conservation****Conservation:** Northern limit (Auburn), rare and probably extinct in Sydney area and at Bathurst.

***Leptorhynchos squamatus* subsp. A**

ASTERACEAE

Scaly Buttons

Life history**Growth form:** Herb to 25 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** October–December (limited data).**Fruit/seed:** Achene with pappus of bristles.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed. Willis and Groves report: Optimal germination regime 20°/10°C. Effect of light on germination — nil. No strong after-ripening requirement. Germination inhibited by high temperature and cold stratification (Willis & Groves 1991).**Fire response:****Interaction with other organisms:** Palatable to rabbits (Leigh et al. 1987).**Distribution****Status/origin:** Native.**Botanical subregions:** NC NT CT ST NWS CWS SWS SWP; Vic., Tas., S.A., W.A.**Distribution Sydney area:** Western Blue Mountains.**Select locations:** Canobolas (1908), Hartley Vale (1913), Moss Vale (1915), Cordeaux Creek, Tuena.**Habitat****Habitat:** Creek bank.**Altitude:** 400–1400 m**Annual rainfall:** above 800 mm**Typical local abundance:** Rare.**Vegetation:** Grasslands and forests. Ground stratum.**Substrate:****Exposure:****Conservation****Conservation:** Rare, mostly old records (5 specimens).***Leucanthemum vulgare* subsp. *maximum* ***

ASTERACEAE

Oxeye Daisy

Life history**Growth form:** Erect, herb 30–90 cm high.**Vegetative spread:** Extensive creeping roots produce new aerial growth annually (Parsons & Cuthbertson 1992).**Longevity:** Perennial.**Primary juvenile period:** More than 1 year (Parsons & Cuthbertson 1992).**Flowers:** White, disc bright yellow, November–February.**Fruit/seed:** Achene 2.5 mm long. Seed produced in summer after which the aerial growth dies back; seed production is prolific, most seed is viable even after passing through the digestive tract of animals (Parsons & Cuthbertson 1992).**Dispersal, establishment & growth:** Diaspore: fruit. No special adaptations for dispersal but small seeds spread in mud on animals and vehicles, water, grain; wind-dispersed along roadsides possibly assisted by turbulence from heavy vehicles (A. Rodd pers. comm.); germination in autumn, develops slowly during winter and spring, an extensive root system develops with shallow laterals which produce new aerial growth each autumn; some seed remains dormant for at least 20 years (Parsons & Cuthbertson 1992). Tolerates infrequent mowing.**Fire response:****Interaction with other organisms:** Grows so densely it excludes most other vegetation, not readily grazed by stock so reduces carrying capacity of farmland (Parsons & Cuthbertson 1992).**Distribution****Status/origin:** Naturalised exotic, native to Europe. Introduced as garden ornamental, naturalised in Victoria by 1905 and since then in NSW (Parsons & Cuthbertson 1992).**Botanical subregions:** NC NT CT ST; Vic., S.A., Tas.

Distribution Sydney area: Tablelands.

Select locations: Lawson (1911), Mt Wilson (1914), Kowmung River, Orange (1906), Fitzroy Falls, Robertson (P. Kodala pers. comm.), Wildes Meadow, Belanglo.

Habitat

Habitat: Roadsides and cleared land, creek channels, disturbed sites.

Altitude: 200–1000 m **Annual rainfall:** above 800 mm

Typical local abundance: Frequent.

Vegetation: Woodland, roadsides, and pastures.

Substrate: Sandstone, basalt, alluvium, fertile–infertile soil. Watertable mostly low. Heavy, damp soil (Parsons & Cuthbertson 1992).

Exposure:

Conservation

Conservation: 'Dreaded pest' at Mt Wilson where it has already rendered useless large areas of land (J.H. Maiden 1914). Presently spread along Bells Line of Road as far as Mt Tomah and probably still spreading (A. Rodd pers. comm. 1994).

Leucochrysum albicans subsp. *albicans* var. *tricolor*

ASTERACEAE

Life history

Growth form: Woolly herb with woody rootstock, to 45 cm high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Pale brown–white, October–April, peak October.

Fruit/seed: Achene 2–3 mm long with pappus of feather-like bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CT ST CWS; Vic., Tas.

Distribution Sydney area: West of area.

Select locations: Hill End, Abercrombie, Trunkey Creek, Picton–Mittagong, Berrima, Wingello, Tallong.

Habitat

Habitat:

Altitude: 600–1000 m **Annual rainfall:** above 800 mm

Typical local abundance:

Vegetation:

Substrate: Sandstone and other sedimentary rock, deep soils.

Exposure:

Conservation

Conservation: Mostly old collections. Conservation status unknown.

Leucochrysum albicans subsp. *albicans* var. *albicans*

ASTERACEAE

(*Helipterum albicans*)

Life history

Growth form: Woolly herb with woody rootstock to 45 cm high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Pale brown–yellow, August–April.

Fruit/seed: Achene 2–3 mm long with pappus of feather-like bristles, mature March (limited data).

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed. Willis and Grove (1991) report: Optimal germination regime 20°/10°C (90–80 %). No effect of light on

germination. No strong after ripening requirement. Dormancy broken by GA₃, high temperature, cold-stratification.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC NT CT ST NWS CWS SWS NWP SWP NFWP; Qld, Vic., Tas.

Distribution Sydney area: Bathurst area.

Select locations: Jenolan Caves (1899), Hartley Vale, Zig Zag, Megalong Creek, Kirkconnel/Bowenfels (1904).

Habitat

Habitat:

Altitude: 700–1000 m **Annual rainfall:** 600–1000 mm

Typical local abundance: Now rare in area.

Vegetation: Grasslands and tall forests. Ground stratum.

Substrate: Shallow soil over sandstone, clay soils, infertile.

Exposure:

Conservation

Conservation: Rare — mostly old records (8 specimens). Conservation status unknown.

***Leucochrysum graminifolium* (Helipterum albicans var. graminifolium) ASTERACEAE**

Life history

Growth form: Erect, tufted herb with woody rootstock, to 20 cm high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, November–July.

Fruit/seed: Achene 2–3 mm long with pappus of feather-like bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC CT.

Distribution Sydney area: Newnes Plateau.

Select locations: Wolgan Gap, Newnes Plateau, Glowworm Tunnel, Zig Zag, Clarence.

Habitat

Habitat: Rock outcrops, crevices, ironstone shelves and ledges.

Altitude: above 900 m **Annual rainfall:** 900–1100 mm

Typical local abundance: Frequent–occasional.

Vegetation: Open-heath, scrub and woodland; Pagoda rock complex of Benson & Keith 1990.

Substrate: Skeletal sandy soil or dry peaty soil on sandstone, among 'pagoda' rock formations.

Exposure:

Conservation

Conservation: Endemic to Newnes Plateau, conservation status unknown, habitat possibly vulnerable to cliff collapse due to underground mining.

***Madia sativa* ***

ASTERACEAE

Tarweed, Pitchweed

Life history

Growth form: Herb to 2 m high, hairy and strongly perfumed.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, June–September.

Fruit/seed: Achene 4–5 mm long, no pappus.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Chile and Argentina.

Botanical subregions: CT ST SWS; Vic.

Distribution Sydney area: South from Orange district.

Select locations: Orange (1918), Milthorpe (1953), Carcoar (1922).

Habitat

Habitat:

Altitude: above 800 m

Annual rainfall: 1000 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Naturalised weed, status unknown.

Matricaria matricarioides * (Chamomilla suaveolens)

ASTERACEAE

Pineapple Weed

Life history

Growth form: Pineapple-scented herb 8–45 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Disc greenish yellow, no florets. Flowers spring–autumn; insect and self-pollinated (Ciba-Geigy 1968–).

Fruit/seed: Achene 1.2–1.5 mm long, pappus small, scarious.

Dispersal, establishment & growth: Dispersed by wind, animals and humans; germinates in spring (Ciba-Geigy 1968–).

Fire response:

Interaction with other organisms: Medicinal plant (Ciba-Geigy 1968–).

Distribution

Status/origin: Naturalised exotic, native to Europe, Asia, S Africa and possibly N America.

Botanical subregions: CT CWS SWS; Vic., Tas., S.A.

Distribution Sydney area: Orange–Molong.

Select locations: Orange 1983 (only Sydney area record).

Habitat

Habitat: Roadsides, footpaths and disturbed sites.

Altitude: 800–1000 m

Annual rainfall: 1000 mm

Typical local abundance: Occasional.

Vegetation:

Substrate: Loamy soils rich in nutrients (Ciba-Geigy 1968–).

Exposure:

Conservation

Conservation: Appears to be locally naturalised weed. Status unknown.

Melanthera biflora (Wedelia biflora)

ASTERACEAE

Life history

Growth form: Scrambling herb to 1 m high, with opposite leaves.

Vegetative spread: Limited spread possible by rooting at nodes.

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, December–April.

Fruit/seed: Achene 2–4 mm long, pappus absent or with 1–3 non-persistent bristles, 1 mm long, mature December–April.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed. Tertiary sand coloniser (Clarke 1989).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC; LHI, Qld, N.T., Afr., Asia, Pac. I.

Distribution Sydney area: Sea coasts.

Select locations: Maroubra Bay, Cronulla, Werong, Otford, Burning Palms, Shellharbour.

Habitat

Habitat: Beach and rocky slopes near beaches.

Altitude: 0–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent.

Vegetation: Coastal herbland, e.g. with *Lomandra longifolia*, *Scaevola calendulacea*, *Hydrocotyle bonariensis*.

Substrate: Sand dunes, foredune and backdune, shale embankments.

Exposure: Tolerant of sun and shade (Clarke 1989).

Conservation

Conservation: Conservation status unknown.

Microseris lanceolata

ASTERACEAE

Life history

Growth form: Herb with fleshy, tuberous root.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, September–November.

Fruit/seed: Achene 8–10 mm long, with pappus of scales.

Dispersal, establishment & growth:

Fire response: Probably resprouts at ground level or below.

Interaction with other organisms: Tubers were food source for Aborigines. Palatable to rabbits (Leigh et al. 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP SFWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Bathurst–Orange area.

Select locations: Rylstone, Mullion Range, Hill End, Abercrombie Caves, Barbers Creek.

Habitat

Habitat: Steep rocky hillsides.

Altitude: 600–1000 m

Annual rainfall: 700–1000 mm

Typical local abundance: Frequent.

Vegetation: Eucalypt woodland, e.g. *Eucalyptus macrorhyncha*, *E. polyanthemos*, *E. nortonii*, *Angophora floribunda*.

Substrate: Sandy, infertile soil. Watertable permanently low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Conservation status unknown. Possibly needing local conservation?

Olearia argophylla

ASTERACEAE

Native Musk, Silver Shrub

Life history

Growth form: Shrub or small tree to 9 m high, with alternate leaves; musky scent (Floyd 1983). Chromosome number: $N = 54$ (N. Lander pers. comm.).

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White, September–April.

Fruit/seed: Achene with pappus of bristles. Matures December (Floyd 1989).

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms: Foodplant of moth caterpillar *Anthela acuta*; pupation occurs in the foliage or under bark (Coupar & Coupar 1992). Timber could be used for cabinet work but usually too small (Floyd 1983).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Vic., Tas.

Distribution Sydney area: Western Blue Mountains, Southern Highlands, Illawarra.

Select locations: Gosford (1888), Mt Kembla, Macquarie Pass, Robertson, Minnamurra Falls, Mt Tomah, Kanangra Walls, Mt Werong, Hilltop, Kangaroo Valley.

Habitat

Habitat:

Altitude: 0–1200 m

Annual rainfall: above 1000 mm

Typical local abundance:

Vegetation: Tall eucalypt forest, e.g. with *Eucalyptus fastigata*, *E. radiata*, *E. dalrympleana* or rainforest margins, e.g. associated with *Eucryphia moorei*, *Doryphora sassafras* and *Atherosperma moschatum* (Floyd 1983). Remnant patches of warm temperate/cool temperate rainforest at Robertson (P. Kodela pers. comm.).

Substrate: Fertile soils, well-drained but moist, e.g. from Wianamatta Shale, basalt (P. Kodela pers. comm.).

Exposure:

Conservation

Conservation: Conservation status unknown.

Olearia asterotricha

ASTERACEAE

Rough Daisy Bush

Life history

Growth form: Shrub to 2 m high, with alternate leaves. Chromosome number $N = 9$ (N. Lander pers. comm.).

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White, October–July.

Fruit/seed: Achene, silky; pappus of long bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC CT; Vic.

Distribution Sydney area: Blue Mountains, Moss Vale.

Select locations: Wallerawang, Marangaroo, Katoomba, Megalong Valley, Bargo, Hilltop, Bowral, The Gib.

Habitat

Habitat:

Altitude: 0–1000 m

Annual rainfall: above 900 mm

Typical local abundance:

Vegetation: Heath and eucalypt forest.

Substrate: Sandstone, soil infertile.

Exposure:

Conservation

Conservation: Status unknown.

Olearia burgessii

ASTERACEAE

Life history

Growth form: Shrub to 1.8 m high, with alternate leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White, July–November.

Fruit/seed: Achene, 2 mm long, with pappus of long bristles.

Dispersal, establishment & growth: Wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC CT ST.

Distribution Sydney area: Thirlmere–Hilltop (also near Tumbarumba).

Select locations: Burragorang Lookout, Thirlmere, Tahmoor, Hilltop.

Habitat

Habitat:

Altitude: 200–600 m

Annual rainfall: 900–1000 mm

Typical local abundance:

Vegetation: Dry sclerophyll forest.

Substrate: Sandy loam over sandstone or shale.

Exposure:

Conservation

Conservation: Rare, this species is known from two areas some 400 km apart and was last collected in 1971. It appears to warrant the category 3K of Briggs & Leigh 1988 (Lander 1991).

Olearia chrysophylla

ASTERACEAE

Life history

Growth form: Shrub to 3 m high, with opposite leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White, December–January.

Fruit/seed: Achene, with pappus of bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC NT CT.

Distribution Sydney area: Blue Mountains to Orange.

Select locations: Springwood, Jenolan Caves, Oberon, Sunny Corner.

Habitat

Habitat:

Altitude: 500–1000 m

Annual rainfall: above 800 mm

Typical local abundance:

Vegetation: Sclerophyll forest.

Substrate: Granite.

Exposure:

Conservation

Conservation: Status unknown. Few collections, rare.

Olearia cordata

ASTERACEAE

Life history

Growth form: Shrub to 2 m high, with alternate leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Deep blue-mauve, November–April.

Fruit/seed: Achene, silky, with pappus of bristles.

Dispersal, establishment & growth:

Fire response: Resprouts; many seedlings at Yengo (M. Matthes pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC.

Distribution Sydney area:

Select locations: Wollemi Creek, Big Yengo Track, Fernances Trig, St. Albans, Wisemans Ferry.

Habitat

Habitat: Sandstone rocky ridge

Altitude: 0–300 m

Annual rainfall: 800–1000 mm

Typical local abundance: Occasional.

Vegetation: Dry open sclerophyll forest and open shrubland, e.g. with *Angophora bakeri*, *Eucalytus eugenioides*, *E. punctata*.

Substrate: Low-nutrient soils from sandstone, possibly with shale influence.

Exposure:

Conservation

Conservation: A rare local endemic, coded 2RCa by Briggs & Leigh (1988). Known populations appear to be conserved.

Olearia elliptica

ASTERACEAE

Sticky Daisy Bush

Life history

Growth form: Shrub to 2 m high, with alternate leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White, November–May.

Fruit/seed: Achene, with pappus of long bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT NWS CWS NWP; LHI, Qld.

Distribution Sydney area: Widespread.

Select locations: Killara, Stanwell Park, Mt Kembla, Jamberoo, Yerrinbool, Wentworth Falls, Mt Victoria, Carrington Falls, Bundanoon.

Habitat**Habitat:****Altitude:** 0–1000 m**Annual rainfall:** above 900 mm**Typical local abundance:****Vegetation:** Heath, woodland and sclerophyll forest.**Substrate:** Sandy or dark silty soils.**Exposure:****Conservation****Conservation:** Status unknown.***Olearia erubescens*****ASTERACEAE**

Silky Daisy Bush

Life history**Growth form:** Shrub 2 m high with alternate leaves.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** White, September–March.**Fruit/seed:** Achene with pappus of bristles.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST; Vic., Tas., S.A.**Distribution Sydney area:** Blue Mountains.**Select locations:** Glenbrook, Yerranderie, Springwood, Leura, Katoomba, Blackheath, Mt Banks, Clarence, Mittagong.**Habitat****Habitat:****Altitude:** 0–1200 m**Annual rainfall:** above 900 mm**Typical local abundance:****Vegetation:** Dry eucalypt forest.**Substrate:****Exposure:****Conservation****Conservation:** Status unknown but possibly rare. 60% of specimens collected pre 1940.***Olearia glandulosa*****ASTERACEAE****Life history****Growth form:** Shrub to 1.5 m high with alternate leaves.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** White, November–June.**Fruit/seed:** Achene, silky; pappus of bristles.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CT ST; Tas., S.A., W.A.**Distribution Sydney area:** Mittagong southwards.**Select locations:** Wingecarribee Swamp, Hanging Rock Swamp (near Penrose). (Other specimens not available)

	Habitat
Habitat: Near moist gullies, swamps, river banks.	
Altitude: 600–700 m	Annual rainfall: above 1000 mm
Typical local abundance: Rare–occasional.	
Vegetation: Woodland, wet heathlands or sedgeland. Amongst sedges and other herbs (P. Kodela pers. comm.).	
Substrate: Peat, tolerates wetness.	
Exposure: Observed growing in full sun (P. Kodela pers. comm.).	
	Conservation
Conservation: Conservation status unknown.	

<i>Olearia megalophylla</i>	ASTERACEAE
-----------------------------	------------

	Life history
Growth form: Shrub to 2 m high, with alternate or opposite leaves.	
Vegetative spread:	
Longevity:	
Primary juvenile period:	
Flowers: White, December–March.	
Fruit/seed: Achene, with pappus of bristles.	
Dispersal, establishment & growth:	
Fire response:	
Interaction with other organisms:	
	Distribution
Status/origin: Native.	
Botanical subregions: CT ST SWS; Vic.	
Distribution Sydney area: Widespread but rare.	
Select locations: Port Kembla, Bargo, Jenolan Caves, Canobolas SF.	
	Habitat

Habitat:	
Altitude: 0–1000 m	Annual rainfall: above 900 mm
Typical local abundance:	
Vegetation: Moist eucalypt forest.	
Substrate:	
Exposure:	
	Conservation
Conservation: Conservation status unknown, rare. Orange is northern limit.	

<i>Olearia microphylla</i>	ASTERACEAE
----------------------------	------------

Snow Bush	
	Life history
Growth form: Shrub to 2 m high with alternate leaves.	
Vegetative spread:	
Longevity:	
Primary juvenile period:	
Flowers: White, June–October.	
Fruit/seed: Achene with pappus of long bristles, mature June–October.	
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed, possibly colonising disturbed sites.	
Fire response: Mostly killed, only 1 plant observed resprouting from base after high-intensity fire, no seedlings (1/1994) at Lane Cove ; probably also killed by moderate-intensity fire, flowering after moderate–high-intensity fire, most of the viable soil-stored seed probably destroyed by very high-intensity fire (P. Kubiak pers. comm.).	
Interaction with other organisms:	
	Distribution
Status/origin: Native.	

Botanical subregions: NC CC SC NT CT ST NWS CWS; Qld.

Distribution Sydney area: Widespread.

Select locations: Gordon, Lane Cove, Rookwood, Chester Hill, Campbelltown, Port Hacking, Austinmer, Hilltop, The Gib, Bundanoon.

Habitat

Habitat:

Altitude: 0–1000 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent–occasional.

Vegetation: Sclerophyll forest, e.g. with *Eucalyptus sieberi*, *E. sclerophylla*, and heathy scrub.

Substrate: Sandy soils on sandstone, also sandy clay soils, low nutrient.

Exposure:

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.

Olearia myrsinoides

ASTERACEAE

Blush Daisy Bush

Life history

Growth form: Shrub to 1.5 m high, with alternate leaves.

Vegetative spread: Possibly root suckers.

Longevity:

Primary juvenile period:

Flowers: White and violet or pale yellow, November–March.

Fruit/seed: Achene with pappus of bristles.

Dispersal, establishment & growth:

Fire response: Possibly resprouts from root suckers.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Vic., Tas.

Distribution Sydney area: Mainly upper Blue Mountains.

Select locations: Glenbrook, Wentworth Falls, Blackheath, Mt York, Clarence, Portland, Rylstone.

Habitat

Habitat: Eucalypt woodland.

Altitude: 0–1200 m

Annual rainfall: above 1000 mm

Typical local abundance: Occasional.

Vegetation: Open grassland, eucalypt woodlands and swampy areas, e.g. with *Eucalyptus sieberi*, *E. oreades*, *E. dives* (Newnes Plateau Woodland of Benson & Keith 1990).

Substrate: Sandstone soils, medium nutrients.

Exposure:

Conservation

Conservation: Conservation status unknown.

Olearia nernstii

ASTERACEAE

Life history

Growth form: Shrub to 2 m high, with alternate leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White, March–November.

Fruit/seed: Achene, with pappus of long bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Status/origin: Native.		Distribution
Botanical subregions: NC CC NT CT; Qld.		
Distribution Sydney area: Mainly Gosford–Wyong.		
Select locations: Wyong Creek (1893), Ourimbah (1911), Gosford (1888), Yerranderie (1916).		
Habitat:		Habitat
Altitude: 0–200 m	Annual rainfall: above 800 mm	
Typical local abundance:		
Vegetation: Eucalypt forest and open woodland.		
Substrate: Probably clay soils.		
Exposure:		
Conservation: Southern limit, old collections only. Now probably rare in Sydney area.		Conservation

Olearia oliganthema

ASTERACEAE

Growth form: Shrub with alternate leaves.		Life history
Vegetative spread:		
Longevity:		
Primary juvenile period:		
Flowers: Yellow.		
Fruit/seed: Achene.		
Dispersal, establishment & growth:		
Fire response:		
Interaction with other organisms:		
Status/origin: Native.		Distribution
Botanical subregions: CT.		
Distribution Sydney area: Blue Mountains.		
Select locations: Collected twice from 'Blue Mountains' before 1866, and not recorded since (Leigh et al. 1984).		
Habitat:		Habitat
Altitude:	Annual rainfall:	
Typical local abundance:		
Vegetation: Unknown, possibly eucalypt open-forest.		
Substrate: Unknown, but possibly on shale soil.		
Exposure:		
Conservation: Coded 2X, extinct (Briggs & Leigh 1988), last collected 1866.		Conservation

Olearia phlogopappa

ASTERACEAE

Growth form: Shrub to 1 m high, with alternate leaves. Chromosome number $N = 9$ (N. Lander pers. comm.).		Life history
Vegetative spread:		
Longevity:		
Primary juvenile period:		
Flowers: White, November–March.		
Fruit/seed: Achene with pappus of long bristles.		
Dispersal, establishment & growth:		
Fire response:		

Interaction with other organisms:**Distribution****Status/origin:** Native.**Botanical subregions:** NT CT ST; Vic., Tas.**Distribution Sydney area:** Blue Mountains and Southern Highlands.**Select locations:** Leura Gap, Burragorang, Carrington Falls, Kangaroo River Bridge.**Habitat****Habitat:****Altitude:** 0–1000 m**Annual rainfall:** above 1000 mm**Typical local abundance:****Vegetation:** Eucalypt woodland, forest and heath.**Substrate:****Exposure:****Conservation****Conservation:** Possibly rare, conservation status unknown.***Olearia quercifolia*****ASTERACEAE****Life history****Growth form:** Shrub to 2 m high, with alternate leaves.**Vegetative spread:** No.**Longevity:****Primary juvenile period:****Flowers:** White, July, November–December.**Fruit/seed:** Achene, silky, with pappus of long bristles.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CT.**Distribution Sydney area:** Upper Blue Mountains.**Select locations:** Mt Wilson, Mt Tomah, Newnes Plateau.**Habitat****Habitat:** Swampy or moist terrain.**Altitude:** 800–1200 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Occasional.**Vegetation:** Margins of shrub swamps, e.g. Newnes Plateau Shrub-swamps (Benson & Keith 1990).**Substrate:** Peaty soils on sandstone, periphery of swamps, very infertile, watertable mostly high.**Exposure:** Full sun–light shade.**Conservation****Conservation:** Restricted local endemic, coded 3RC in Briggs & Leigh (1988), vulnerable to changes in water flow and water quality and in its swamp habitat.***Olearia ramosissima*****ASTERACEAE****Life history****Growth form:** Shrub to 1.3 m high with alternate leaves.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** Blue–mauve, June–August.**Fruit/seed:** Achene, silky, with pappus of 27–47 long bristles.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

		Distribution
Status/origin: Native.		
Botanical subregions: CC CT NT NWS SWP; Qld, W.A.		
Distribution Sydney area: Shoalhaven River gorge (Harden 1992).		
Select locations: Specimens unavailable.		
		Habitat
Habitat:		
Altitude:	Annual rainfall:	
Typical local abundance:		
Vegetation: Sclerophyll forest (Harden 1992).		
Substrate:		
Exposure:		
		Conservation
Conservation:		

Olearia ramulosa

ASTERACEAE

		Life history
Growth form: Shrub to 1.6 m high, scabrous, pubescent, sometimes sticky. Chromosome number N = 9 (N. Lander pers. comm.).		
Vegetative spread:		
Longevity:		
Primary juvenile period:		
Flowers: Pale blue or mauve or white, October–May. Insect-pollinated (Sulman 1914).		
Fruit/seed: Achene, with pappus of 20–40 long bristles.		
Dispersal, establishment & growth: Wind-dispersed.		
Fire response:		
Interaction with other organisms:		
		Distribution
Status/origin: Native.		
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Vic., Tas., S.A.		
Distribution Sydney area: Widespread.		
Select locations: Specimens unavailable.		
		Habitat
Habitat: Hilly terrain (Harden 1992).		
Altitude:	Annual rainfall:	
Typical local abundance:		
Vegetation: Tall open-forest.		
Substrate: Shales, medium to high nutrient.		
Exposure:		
		Conservation
Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).		

Olearia rosmarinifolia

ASTERACEAE

		Life history
Growth form: Shrub to 1.6 m high, hoary or silvery.		
Vegetative spread:		
Longevity:		
Primary juvenile period:		
Flowers: White, October–December.		
Fruit/seed: Achene, with pappus of 60–84 bristles.		
Dispersal, establishment & growth:		
Fire response:		
Interaction with other organisms:		

Distribution

Status/origin: Native.

Botanical subregions: NT CT ST NWS CWS; Qld.

Distribution Sydney area: Western parts of area.

Select locations: Specimens unavailable.

Habitat

Habitat: Rocky areas around riverbeds and gorges (Harden 1992).

Altitude:

Annual rainfall:

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation:

Olearia stellulata* (Olearia lirata)*ASTERACEAE****Life history**

Growth form: Shrub to 3 m high with alternate leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White, August–January.

Fruit/seed: Achene, silky, with pappus of bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC NT CT ST; Vic., Tas.

Distribution Sydney area:

Select locations: Specimens unavailable.

Habitat

Habitat: Hillsides and creekbanks (Harden 1992).

Altitude:

Annual rainfall:

Typical local abundance:

Vegetation: Sclerophyll forest (Harden 1992).

Substrate:

Exposure:

Conservation

Conservation:

Olearia suffruticosa**ASTERACEAE****Life history**

Growth form: Shrub to 0.7 m high with alternate leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White or pink, January–May.

Fruit/seed: Achene, silky, with pappus of bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CT; Vic., S.A.

Distribution Sydney area:

Select locations: Specimens unavailable.

Habitat

Habitat:

Altitude:

Annual rainfall:

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation:

Olearia tenuifolia

ASTERACEAE

Life history

Growth form: Shrub to 2 m high with alternate leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Blue or mauve, at any time of year.

Fruit/seed: Achene, with pappus of bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: SC CT ST CWS SWS SWP; Vic.

Distribution Sydney area:

Select locations: Specimens unavailable.

Habitat

Habitat: Rocky areas (Harden 1992).

Altitude:

Annual rainfall:

Typical local abundance:

Vegetation: Dry sclerophyll forest, mallee and woodland (Harden 1992).

Substrate:

Exposure:

Conservation

Conservation:

Olearia tomentosa

ASTERACEAE

Life history

Growth form: Shrub to 2 m high with alternate leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Blue or white, August–May.

Fruit/seed: Achene, with pappus of bristles.

Dispersal, establishment & growth:

Fire response: Probably most killed by high-intensity fire (1/1994) at Narrabeen, a few suckering plants observed (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC CT ST.

Distribution Sydney area: Widespread including exposed headlands on coast.

Select locations: Listed in national park areas from Brisbane Water NP to Sydney Harbour NP. Barrenjoey headland and Mona Vale (L.McD.). Specimens unavailable.

Habitat:

Altitude:

Annual rainfall:

Typical local abundance:

Vegetation: Dry sclerophyll forest, scrub and heath (Harden 1992).

Substrate: Sandstone

Exposure:

Habitat

Conservation: Conserved in Western Sydney (Benson & McDougall 1991).

Conservation

Olearia viscidula

ASTERACEAE

Wallaby Weed

Growth form: Viscid shrub to 2.5 m high with alternate or opposite leaves.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White, July–November.

Fruit/seed: Achene, silky, with pappus of 27–37 long bristles.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Life history

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS; Vic.

Distribution Sydney area: Coast to Blue Mountains.

Select locations: Specimens unavailable.

Distribution

Habitat:

Altitude:

Annual rainfall:

Typical local abundance:

Vegetation: Eucalypt tall open-forest and rainforest. Dry sclerophyll forest and eucalypt woodland (Harden 1992).

Substrate: Medium-high nutrient soils.

Exposure:

Habitat

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).

Conservation

Onopordum acanthium subsp. *acanthium* *

ASTERACEAE

Scotch Thistle

Growth form: Biennial herb to 1 m high.

Vegetative spread: No.

Longevity: 2 years.

Primary juvenile period:

Flowers: Florets purple, September–December.

Fruit/seed: Achene 4–5 mm long, with pappus of barbed bristles 7–9 mm long.

Dispersal, establishment & growth: Diaspore fruit, wind-dispersed. Pioneer species, establishing on bare soil after, e.g. roadbuilding or soil erosion (Doing et al. 1969).

Fire response:

Interaction with other organisms: Foodplant of butterfly caterpillar *Vanessa kershawi* (Coupar & Coupar 1992). Weevil *Larinus latus* the first biological control agent for *Onopordum* spp., released in 1992, destroys seeds (Tanner 1993).

Life history

Status/origin: Naturalised exotic, native to Europe. Botanical subregions: CC NT CT ST CWS SWS NWP SWP SFWP; Vic., Tas., S.A. Distribution Sydney area: Flemington, Orange. Select locations: Flemington Saleyards (1968, 1980), Orange (1941).	Distribution
Habitat: Cultivated areas, saleyards. Altitude: 0–1000 m Annual rainfall: 1000 mm Typical local abundance: Rare. Vegetation: Thistle communities, roadside and riverbank vegetation mainly with <i>Cirsium vulgare</i> , <i>Carduus nutans</i> , <i>C. tenuiflorus</i> , <i>C. pycnocephalus</i> , <i>Silybum marianum</i> or grassland communities with <i>Hordeum leporinum</i> , <i>Bromus diandrus</i> , <i>B. hordeaceus</i> etc. (Doing et al. 1969). Substrate: Replaces <i>Carduus nutans</i> on limestone and coarse sandy soils, fertile soils with moisture holding capacity (Doing et al. 1969). Exposure:	Habitat
Conservation: Naturalised weed, declared noxious in many shires of NSW.	Conservation

Osteospermum ecklonis* **ASTERACEAE**

Growth form: Shrub or subshrub to 100 cm high. Vegetative spread: Appears to root along stems. Longevity: Primary juvenile period: Flowers: White and blue-violet, disc azure blue, April–December. Fruit/seed: Achene 7 mm long, no pappus. Dispersal, establishment & growth: Fire response: Interaction with other organisms:	Life history
Status/origin: Naturalised exotic, native to S Africa, introduced as garden ornamental. Botanical subregions: CC; Qld. Distribution Sydney area: Suburban areas. Select locations: Blackwall Mtn, Palm Beach, Cheltenham, Ingleburn, Macquarie Fields (1941), Campbelltown, Orangeville.	Distribution
Habitat: Footpaths, wasteland, beaches, roadsides. Altitude: 0–300 m Annual rainfall: above 800 mm Typical local abundance: Occasional. Vegetation: Wasteland weeds. Substrate: Sandy soils, e.g. beaches, and loamy soils from shales, low–moderately fertile. Exposure: Full sun.	Habitat
Conservation: Probably mainly localised garden escape from rubbish dumping.	Conservation

Ozothamnus adnatus* (Helichrysum adnatum)*ASTERACEAE**

Growth form: Heath-like shrub 1–2 m high. Vegetative spread: Longevity: Primary juvenile period: Flowers: Cream, October–December. Fruit/seed: Achene with pappus of bristles, November–January. Dispersal, establishment & growth: Fire response: Interaction with other organisms:	Life history
---	---------------------

Distribution

Status/origin: Native.

Botanical subregions: CC NT CT ST; Vic.

Distribution Sydney area: Coast and Blue Mountains.

Select locations: Hurstville (1900), Oatley, Waterfall, Thirlmere Lakes, Glenbrook, Scotts Main Range, Bullaburra, Katoomba, Moorara Boss, Jenolan Caves, Hilltop.

Habitat

Habitat: Hillsides.

Altitude: 0–1000 m

Annual rainfall: above 800 mm

Typical local abundance: Occasional–rare.

Vegetation: Dry eucalypt forest, e.g. with *Syncarpia glomulifera*, *Eucalyptus gummifera*, *E. punctata*, *E. sieberi*, *E. sideroxylon*.

Substrate: Sandy to sandy loam to shaley soils from sandstone, infertile. Watertable mostly low.

Exposure:

Conservation

Conservation: Rare, conservation status unknown.

Ozothamnus argophyllus* (Helichrysum argophyllum)*ASTERACEAE****Life history**

Growth form: Aromatic shrub to 2.5 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Spring–summer. October–November.

Fruit/seed: Achene with pappus of bristles, mature December.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC NT CT ST; Vic., Tas., S.A.

Distribution Sydney area: Coast.

Select locations: Pearl Beach, Mt Kembla, Shellharbour (1899), Berry, Kangaroo Valley, Robertson, Bombaderry.

Habitat

Habitat: Eucalypt forest and edge of rainforest.

Altitude: 0–600 m

Annual rainfall: above 1200 mm

Typical local abundance:

Vegetation: Tall eucalypt forests, edge of rainforest.

Substrate: High nutrient soils, basalt.

Exposure:

Conservation

Conservation: Conservation status unknown.

Ozothamnus diosmifolius* (Helichrysum diosmifolium)*ASTERACEAE**

White Dogwood

Life history

Growth form: Much branched shrub to 5 m high with white flowers.

Vegetative spread: No.

Longevity: Probably medium.

Primary juvenile period:

Flowers: White or pink, October–January, peak November.

Fruit/seed: Achene with pappus of fine hairs, matures December–January.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed (Westoby et al. 1990).

Fire response: Resprouted at Agnes Banks (Benson 1981). Most killed by high-intensity fire

(1/1994) at Lane Cove, a few scattered plants resprouted from base and some plants resprouted from stems after lower fire intensities, scattered occurrence of seedlings (P. Kubiak pers. comm.).

Interaction with other organisms: Known to cause severe contact allergy in humans (Bass 1987).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS NWP SWP; Qld.

Distribution Sydney area: Widespread.

Select locations: Howes Mountain, Spencer, Cheltenham, Otford, Minamurra Falls, Kurrajong, St Marys, Yerranderie, Hill Top, Mt Corricudgy, Kandos, Wildes Meadow (P. Kodela pers. comm.).

Habitat

Habitat: Open-forest, a tall open-forest.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Tall moist forests, e.g. with *Eucalyptus saligna*, *E. cypellocarpa* or *E. fastigata*, to dry forests, e.g. with *Eucalyptus fibrosa*, *E. tereticornis*.

Substrate: Clay soils, fertile, from Wianamatta Shale, volcanics, sometimes sandstones. Recorded on saline soils near Lower Boro (Kodela & Foster 1990).

Exposure:

Conservation

Conservation: Probably adequate. Conserved in Western Sydney (Benson & McDougall 1991).

Ozothamnus ferrugineus (Helichrysum dendroideum)

ASTERACEAE

Tree Everlasting

Life history

Growth form: Erect shrub or small tree 2–5 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Summer–autumn.

Fruit/seed: Achene, with pappus of bristles.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed locally.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT; Vic., Tas., S.A.

Distribution Sydney area: Mainly upper Blue Mountains.

Select locations: Kiama (1888), Mt Coricudgy, Mt Tomah, Jenolan Caves Road, Mt Murray, Foxground, Bundanoon.

Habitat

Habitat: Ridges and hillsides.

Altitude: 0–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent–occasional.

Vegetation: Open eucalypt forest and scrub.

Substrate: Basalt soil, high nutrient.

Exposure:

Conservation

Conservation: Conservation status unknown.

Ozothamnus rosmarinifolius (*Helichrysum rosmarinifolium*)

ASTERACEAE

Life history**Growth form:** Shrub to 1.5 m high.**Vegetative spread:****Longevity:** ?**Primary juvenile period:****Flowers:** Golden, January–February.**Fruit/seed:** Achene with pappus of bristles, mature February.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CT ST; Vic., Tas.**Distribution Sydney area:** Jenolan–Oberon area.**Select locations:** Jenolan Caves (1899), Boyd River, Duckmaloi River, Gurnang SF.**Habitat****Habitat:****Altitude:** 800–1200 m**Annual rainfall:** 800–1000 mm**Typical local abundance:****Vegetation:** Eucalypt forest, often beside water courses.**Substrate:****Exposure:****Conservation****Conservation:** Conservation status unknown.***Picris hieracioides* ***

ASTERACEAE

Hawkweed *Picris***Life history****Growth form:** Erect herb 30–80 cm high.**Vegetative spread:** No.**Longevity:** 2 years.**Primary juvenile period:****Flowers:** Yellow, most of the year.**Fruit/seed:** Achene 6–9 mm long, with pappus of plumed bristles 8 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.**Fire response:****Interaction with other organisms:** Palatable to rabbits (Leigh et al. 1987).**Distribution****Status/origin:** Naturalised exotic, native to Europe, Asia, Africa.**Botanical subregions:** NC CC SC NT ST NWS NFWP SFWP; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:** Colo River area.**Select locations:** Culoul Range (1976) only record for Sydney area.**Habitat****Habitat:** Weed of disturbed areas.**Altitude:** 600 m**Annual rainfall:** 800 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:**

Podolepis canescens

ASTERACEAE

Large Copper-wire Daisy

Life history**Growth form:** Woolly herb to 80 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Straw-coloured, March.**Fruit/seed:** Achene 2 mm long, with pappus of bristles.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CT CWS NWP SWP NFWP SFWP; Vic., N.T., S.A., W.A.**Distribution Sydney area:** Bathurst.**Select locations:** Hill End (1885), Bathurst (1894, 1901) only records for Sydney area.**Habitat****Habitat:****Altitude:** 800 m**Annual rainfall:** 700 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Rare in area, possibly extinct.***Podolepis hieracioides***

ASTERACEAE

Life history**Growth form:** Herb to 70 cm high, with long taproot.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Yellow, January–March.**Fruit/seed:** Achene 3 mm long, with pappus of bristles, mature January–March.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NT CT ST; Vic.**Distribution Sydney area:** Mainly western Blue Mountains.**Select locations:** Ben Bullen, Marrangaroo Creek, Little Hartley, Duckmaloi, Oberon/Jenolan Road, Burragarang Valley, Bargo River, Bowral.**Habitat****Habitat:****Altitude:** 500–1200 m**Annual rainfall:** above 900 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Moist eucalypt forest, e.g. with *Eucalyptus cypellocarpa*, *E. viminalis*, *E. radiata*, *E. ovata*, and grassland.**Substrate:** Clay loam from shales and slatey shales.**Exposure:****Conservation****Conservation:** Conservation status unknown (50% of Herbarium collections pre 1940).

Podolepis jaceoides

ASTERACEAE

Showy Copper-wire Daisy

Life history**Growth form:** Herb to 70 cm high, with several stems arising from perennial stock each year.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Yellow, August–January.**Fruit/seed:** Achene 3 mm long, with pappus of bristles.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed**Fire response:****Interaction with other organisms:** Palatable to rabbits (Leigh et al. 1987).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP;
Qld, Vic., Tas., S.A.**Distribution Sydney area:** Widespread.**Select locations:** Otford, Mt Kembla, Nepean Dam Road, Thirlmere, Mt Victoria, Mt Werong, Moorara Boss, Bowral, Long Swamp.**Habitat****Habitat:** 'Amongst grasses in open situations and forest land' (Davis 1956).**Altitude:** 0–1000 m **Annual rainfall:** above 900 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Grassy woodland, e.g. with *Eucalyptus sieberi*, *E. blaxlandii*, *E. obliqua* and grassy slopes of swamp margins.**Substrate:** Sandy to clay soil from shale, granite, fertile–infertile.**Exposure:****Conservation****Conservation:** Status unknown but probably becoming increasingly rare.***Pseudognaphalium luteoalbum*** (*Gnaphalium luteo-album*)

ASTERACEAE

Jersey Cudweed

Life history**Growth form:** Erect, greyish–white, woolly herb to 45 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** At any time of year.**Fruit/seed:** Achene 0.6 mm long, with pappus of bristles 3 mm long, mature September–May.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed locally. Coloniser.**Fire response:** Probably killed.**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP;
Qld, Vic., Tas., N.T., S.A., W.A., almost cosmopolitan.**Distribution Sydney area:** Coast and western Blue Mountains.**Select locations:** Awaba, Hornsby, Como, Bulli Pass, Gerringong, Camden, Silverdale, Blackheath, Clarence, Mt Blaxland, Robertson (P. Kodela pers. comm.).**Habitat****Habitat:** Grassland, watercourses, saltmarsh flats, swamps.**Altitude:** 0–1100 m **Annual rainfall:** above 700 mm**Typical local abundance:** Frequent.**Vegetation:** Grasslands and open areas, e.g. with *Juncus*, *Cyperus*. Swamps, pastures (P. Kodela pers. comm.).**Substrate:** Sandy soils, infertile, watertable mostly high, fresh–? brackish. More fertile

situations in the Robertson area (P. Kodela pers. comm.).

Exposure: Full sun.

Conservation: Conserved in Western Sydney (Benson & McDougall 1991), status elsewhere unknown.

Conservation

Rhodanthe anthemoides (Helipterum anthemoides)

ASTERACEAE

Life history

Growth form: Erect, bushy herb with many slender stems arising from perennial root-stock.

Vegetative spread: Probably not.

Longevity: Possibly short-lived, less than 5 years.

Primary juvenile period:

Flowers: Pale brown, May–December.

Fruit/seed: Achene 2 mm long, with silky pappus.

Dispersal, establishment & growth: Diaspore: fruit, locally wind-dispersed. Seedling recruitment probably not fire-related though in subalpine habitats is common on exposed slopes especially after fire or disturbance (Burbidge & Gray 1976). Population at Mt Annan expanding in absence of grazing and fire.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT CT ST NWS CWS SWS; Qld, Vic., Tas.

Distribution Sydney area: Southwestern Sydney.

Select locations: Bringelly, Mt Annan, Razorback.

Habitat

Habitat: Woodland.

Altitude: 0–300 m

Annual rainfall: 700–800 mm

Typical local abundance: Frequent.

Vegetation: Grasslands and tall forests, woodland of *Eucalyptus moluccana*–*E. tereticornis* with grassy understorey. Ground stratum.

Substrate: Fertile, clay soils from Wianamatta Shale. Watertable mostly low, moisture supply intermittent, fresh.

Exposure: Sheltered sites; light shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).

Rhodanthe pygmaea (Helipterum pygmaeum)

ASTERACEAE

Pigmy Sunray

Life history

Growth form: Sparsely woolly herb to 6 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: August.

Fruit/seed: Achene 2.5 mm long, with pappus of bristles 5–7 mm long.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native in western NSW, but introduced to Central Coast.

Botanical subregions: CC* ST NWS CWS SWS NWP SWP NFWP SFWP; Vic., S.A., W.A.

Distribution Sydney area: Flemington.

Select locations: Flemington (1968) only record.

Habitat

Habitat: Saleyard.

Altitude: 0–100 m

Annual rainfall: 900 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Probably introduced to Flemington from western NSW with stock, and now unlikely to occur there.

Roldana petasitis * (Senecio petasitis)

ASTERACEAE

Life history

Growth form: Shrub or herb, mostly 1.5–2 m high, softy hairy.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, August–October.

Fruit/seed: Achene 2.5–4 mm long, with pappus of slender hairs 8–10 mm long, not persistent.

Dispersal, establishment & growth:

Fire response: Resprouted after high-intensity fire (1/1994) at Lane Cove, flowers in bud within 30 weeks (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Mexico. Cultivated as an ornamental.

Botanical subregions: NC CC; LHI, Qld.

Distribution Sydney area:

Select locations: Galston (J. Howell), Epping, Lane Cove, Rookwood, Campbelltown (1969), Kembla Grange (1967), Macquarie Pass.

Habitat

Habitat: Roadsides, railway lines, disturbed areas.

Altitude: 0–300 m

Annual rainfall: above 800 mm

Typical local abundance:

Vegetation: Tall eucalypt forest.

Substrate: Medium-nutrient soils, e.g. from Wianamatta Shale.

Exposure:

Conservation

Conservation: Occasionally naturalised.

Schkuhria pinnata var. *abrotanoides**

ASTERACEAE

Dwarf Marigold

Life history

Growth form: Much-branched herb to 50 cm high.

Vegetative spread:

Longevity: Probably short-lived (1–2 years).

Primary juvenile period:

Flowers: Yellow, March–April.

Fruit/seed: Achene 4 mm long, with pappus of scales, mature April.

Dispersal, establishment & growth: Diaspore: fruit.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Chile.

Botanical subregions: NC CC NT NWS CWS NWP SWP; Qld, Vic.

Distribution Sydney area: Mainly western Sydney.

Select locations: Flemington, Miranda (1925), Dural, Rouse Hill, Doonside.

Habitat

Habitat: Disturbed sites and roadsides.

Altitude: 0–100 m

Annual rainfall: above 800 mm

Typical local abundance: Occasional.

Vegetation:

Substrate: Clay soils from Wianamatta Shale.

Exposure:

Conservation

Conservation: Naturalised roadside weed, rare.

Senecio amygdalifolius

ASTERACEAE

Life history

Growth form: Herb or shrub, mostly 80–150 cm high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period: Probably less than 1 year (Lawrence 1985).

Flowers: October. Probably native bee-pollinated, self-incompatible (Lawrence 1985).

Fruit/seed: Achene 4–6 mm long, with pappus of hairs 8–10 mm long, mature November.

Potential seed set/plant 500–1000; seed weight without pappus 1.85 mg (Lawrence 1985).

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed. Germinates readily without treatment when fresh.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT NWS; Qld.

Distribution Sydney area: North from Morisset.

Select locations: Morisset (1959) only record for Sydney area.

Habitat

Habitat:

Altitude: 0–100 m

Annual rainfall: 1100 mm

Typical local abundance: Frequent.

Vegetation: Open eucalypt forest, disturbed.

Substrate: High nutrient soils, disturbed sites.

Exposure:

Conservation

Conservation: Morisset (southern limit), conservation status unknown.

Senecio anacampserotis

ASTERACEAE

Life history

Growth form: Herb, stems prostrate then erect, 15–50 cm long.

Vegetative spread: Creeping, rooting at nodes along stems.

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, August–December.

Fruit/seed: Achene 5 mm long, with appressed white hairs and pappus 7–8 mm long.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Tas.

Distribution Sydney area: Coastal.

Select locations: Wamberal, Dee Why Beach, Kurnell, Cronulla Beach.

Habitat

Habitat: Sand dunes and dune slacks.

Altitude: 0–50 m

Annual rainfall: above 1200 mm

Typical local abundance: Frequent–occasional.

Vegetation:

Substrate: Beach sand dunes, bare moist areas.

Exposure: Full sun.

Conservation

Conservation: Rare (60% of Herbarium records collected pre 1940). Conservation status unknown.

Senecio bipinnatisectus

ASTERACEAE

Life history

Growth form: Erect shrub, 60–120 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: January–March. Probably native bee-pollinated, self-compatible (Lawrence 1985).

Fruit/seed: Achene 2 mm long, with pappus of hairs 5–6 mm long. Potential seed set/plant 5000–15 000 ; seed weight without pappus 0.22 mg (Lawrence 1985).

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed (Westoby et al. 1990), mature March–May. Germination 70% (Lawrence 1985).

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST CWS; Qld.

Distribution Sydney area: Coast and higher mountains.

Select locations: Watagan, Asquith, Blakehurst (1903), Audley, Helensburgh, Mt Keira, Minnamurra, Thirlmere Lakes, Mt Tomah, Govetts Leap, Robertson.

Habitat

Habitat: Gullies, creek banks, swamp.

Altitude: 0–1000 m

Annual rainfall: above 900 mm

Typical local abundance: Rare–occasional.

Vegetation: Heath, woodland and forest.

Substrate: Sandy soils, alluvial, infertile, watertable mostly high, fresh.

Exposure: Mid–deep shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), status elsewhere unknown.

Senecio biserratus

ASTERACEAE

Life history

Growth form: Erect herb, 50–100 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Most of year.

Fruit/seed: Achene 2 mm long, with pappus of hairs 5 mm long.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.

Fire response:

Interaction with other organisms:

Status/origin: Native.		Distribution
Botanical subregions: NC CC SC NT ST; Vic., Tas., S.A., N.Z.		
Distribution Sydney area: Picton, Lithgow.		
Select locations: Mt Walker (Lithgow), Blue Gum Creek (Picton).		
Habitat:		Habitat
Altitude: 0–800 m	Annual rainfall: 900 mm	
Typical local abundance:		
Vegetation: Moist eucalypt forest, e.g. with <i>Eucalyptus deanei</i> or drier woodland, e.g. with <i>Eucalyptus dives</i> , <i>E. mannifera</i> (Mt Walker complex of Keith & Benson 1988).		
Substrate: Soils on sandstone, siltstones or claystones, fertile–infertile, well-drained.		
Exposure:		
Conservation: Rare, conservation status unknown.		Conservation

***Senecio crassiflorus* ***

ASTERACEAE

Growth form: Decumbent herb with silvery white stems 20–50 cm high.		Life history
Vegetative spread:		
Longevity: Perennial.		
Primary juvenile period:		
Flowers: Throughout the year.		
Fruit/seed: Achene 3–5 mm long, with pappus of hairs 14–15 mm long.		
Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.		
Fire response:		
Interaction with other organisms:		
Status/origin: Naturalised exotic, native to S America, introduced as garden ornamental.		Distribution
Botanical subregions: NC CC.		
Distribution Sydney area: Coast near habitation.		
Select locations: Belmont (1947), Cowan (1924).		
Habitat:		Habitat
Altitude: 0–100 m	Annual rainfall: above 1200 mm	
Typical local abundance:		
Vegetation:		
Substrate: Probably sandy soils.		
Exposure:		
Conservation: Sometimes locally naturalised in coastal districts. Cowan–Berowra current southern limit of naturalised distribution.		Conservation

Senecio diaschides

ASTERACEAE

Growth form: Erect herb, 50–100 cm high.		Life history
Vegetative spread:		
Longevity: Short-lived perennial.		
Primary juvenile period:		
Flowers: November–March.		
Fruit/seed: Achene 2.5 mm long, with pappus of hairs 3–5 mm long, mature January–August.		
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.		
Fire response: Killed, seedlings grow vigorously after fire.		
Interaction with other organisms:		

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT CT ST NWS CWS; Qld, Vic., *W.A.

Distribution Sydney area: Widespread.

Select locations: Boarding House Dam, Hornsby, Many Reservoir, Malabar, Engadine, Culoul Range, Doonside, Wilton, Mt Tomah, Clarence, Glanmire, Rockley, Wildes Meadow (P. Kodala pers. comm.).

Habitat

Habitat: Forest, roadsides, creeks.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance:

Vegetation: High rainfall eucalypt forest, e.g. with *Eucalyptus tereticornis*, *E. sieberi* or coastal heath with *Banksia integrifolia*.

Substrate: Usually damp places, clays soil, medium nutrient, from basalt, shale, also sandy soils.

Exposure:

Conservation

Conservation: Conservation status unknown.

Senecio glomeratus

ASTERACEAE

Life history

Growth form: Erect herb mostly 30–100 cm high.

Vegetative spread: No.

Longevity: Short, 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Spring. Probably native bee-pollinated, self-compatible (Lawrence 1985).

Fruit/seed: Achene 1.3–1.7 mm long, with pappus of hairs 5 mm long. Potential seed set/plant 5000–10 000; seed weight without pappus 0.1 mg (Lawrence 1985).

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed. Germination 95% (Lawrence 1985).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC ST CWS SFWP; Vic., Tas., S.A., W.A.

Distribution Sydney area: La Perouse, Western Sydney.

Select locations: La Perouse (1965) only Herbarium record, Prospect (D.H.B.)

Habitat

Habitat:

Altitude: 0–100 m

Annual rainfall: above 1200 mm

Typical local abundance: Rare.

Vegetation:

Substrate: Moist sites, probably on sandy soil from sandstone.

Exposure:

Conservation

Conservation: Not common, vulnerable in Western Sydney (Benson & McDougall 1991). Status elsewhere unknown.

Senecio hispidulus var. *dissectus*

ASTERACEAE

Life history

Growth form: Erect herb, mostly 30–100 cm high, with lower leaves pinnatifid, upper leaves pinnatisect to bipinnatisect.

Vegetative spread:

Longevity: Less than 1 year (Lawrence 1985).

Primary juvenile period: Less than 1 year (Lawrence 1985).

Flowers: Spring–summer. Probably native bee-pollinated, self-compatible (Lawrence 1985).

Fruit/seed: Achene 1.5–2.5 mm long, with pappus of hairs 5 mm long, mature January–April. Potential seed set/plant 3000–10 000; seed weight without pappus 1.2 mg (Lawrence 1985).
Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.
 Germination 90% (Lawrence 1985).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT CT ST NWS CWS NWP SWP; Qld, Vic.

Distribution Sydney area: Mainly Bathurst–Orange.

Select locations: Doonside, Capertee, Orange, Mandurama, Carcoar, Bowral.

Habitat

Habitat: Disturbed sites.

Altitude: 0–1000 m

Annual rainfall: above 800 mm

Typical local abundance: Rare.

Vegetation:

Substrate: Clay and gravelly soil, basalt, fertile.

Exposure:

Conservation

Conservation: Not known.

Senecio hispidulus* var. *hispidulus

ASTERACEAE

Hill Fireweed

Life history

Growth form: Erect herb, mostly 30–100 cm high, leaves more or less lanceolate or oblanceolate — margins finely to coarsely toothed or more or less pinnatifid.

Vegetative spread: No.

Longevity: Less than 1 year (Lawrence 1985).

Primary juvenile period: Less than 1 year (Lawrence 1985).

Flowers: At any time of year. Probably native bee-pollinated, self-compatible (Lawrence 1985).

Fruit/seed: Achene 1.5–2.7 mm long, with pappus of hairs 5 mm long, mature October–June.

Potential seed set/plant 5000–10 000; seed weight without pappus 0.15 mg (Lawrence 1985).

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed. Recruitment mainly after fire (D. Keith pers.comm.). Germination 95% (Lawrence 1985).

Fire response: Killed by fire (D. Keith pers.comm.). Flowers within 33 weeks of high-intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS SWS; Qld, Vic., Tas., W.A.

Distribution Sydney area: Coast and lower mountains.

Select locations: Putty, Avoca, Pymble, Rookwood, La Perouse, Otford, Shellharbour, Grose Vale, Nortons Basin, Thirlmere, Mt Tomah, Bowral.

Habitat

Habitat: Forest and coastal headlands, disturbed sites.

Altitude: 0–1000 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent.

Vegetation: Moist eucalypt forest, e.g. *Eucalyptus saligna*, to drier forest, e.g. *Eucalyptus piperita*, *E. eugenioides*.

Substrate: Sandy loams from shaded, sandstone, infertile.

Exposure: Sheltered sites, light–no shade.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), status elsewhere unknown.

***Senecio jacobaea* ***

ASTERACEAE

Ragwort

Life history**Growth form:** Rhizomatous herb, mostly 30–80 cm high.**Vegetative spread:** Rhizomatous.**Longevity:** Perennial or biennial.**Primary juvenile period:****Flowers:** Autumn.**Fruit/seed:** Achene 2 mm long, with pappus of hairs 5–6 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe and Asia.**Botanical subregions:** CT ST; Vic., Tas., S.A., W.A.**Distribution Sydney area:** Kangaloon.**Select locations:** Kangaloon (1938) only Sydney record.**Habitat****Habitat:** Cultivated land.**Altitude:** 800 m**Annual rainfall:** 1500 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Rare, collected at Kangaloon and Goulburn, rare (Harden 1992).

Weed of cultivation, unlikely to be a problem weed.

Senecio lautus* subsp. *dissectifolius

ASTERACEAE

Variable Groundsel

Life history**Growth form:** Herb or small shrub.**Vegetative spread:****Longevity:** Perennial (Lawrence 1985).**Primary juvenile period:** Probably less than 1 year (Lawrence 1985).**Flowers:** March–October. Probably native bee-pollinated, self-incompatible (Lawrence 1985).**Fruit/seed:** Achene 2 mm long with pappus of hairs 5 mm long, mature March–October.

Potential seed set 5000–10 000; seed weight without pappus 0.23 mg (Lawrence 1985).

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed. Germination 80% (Lawrence 1985).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.**Distribution Sydney area:** Mainly western Blue Mountains.**Select locations:** Kincumber (1905), Tempe (1899), Jenolan Caves, South Megalong, Mt Werong, Mt Canobolas, Mt Jellore, Bowral.**Habitat****Habitat:** Rocky outcrops, hillsides, creekbeds.**Altitude:** 0–1000 m**Annual rainfall:** above 900 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Dry eucalypt forest and woodland.**Substrate:** Rocky sites on granite, basalt, metamorphics.**Exposure:****Conservation****Conservation:** Status unknown.

Senecio lautus* subsp. *lanceolatus

ASTERACEAE

Variable Groundsel

Life history**Growth form:** Herb or subshrub.**Vegetative spread:****Longevity:** Perennial (Lawrence 1985).**Primary juvenile period:** Probably less than 1 year (Lawrence 1985).**Flowers:** March–July (limited data). Probably native bee-pollinated, self-incompatible (Lawrence 1985).**Fruit/seed:** Achene 3 mm long, with pappus of hairs 5 mm long. Potential seed set/plant 10 000–20 000; seed weight without pappus 0.29 mg (Lawrence 1985).**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed. Germination 85% (Lawrence 1985).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT; Qld, Vic., W.A.**Distribution Sydney area:****Select locations:** Maroubra (1893), Yerranderie, Kowmung River.**Habitat****Habitat:** Ridgetops.**Altitude:** 0–800 m**Annual rainfall:** above 800 mm**Typical local abundance:** Occasional.**Vegetation:** Open-forest.**Substrate:****Exposure:****Conservation****Conservation:** Not known.***Senecio lautus* subsp. *maritimus***

ASTERACEAE

Variable Groundsel

Life history**Growth form:** Herb or small shrub.**Vegetative spread:****Longevity:** Perennial (Lawrence 1985).**Primary juvenile period:** Probably less than 1 year (Lawrence 1985).**Flowers:** March–October. Probably native bee-pollinated; self-incompatible (Lawrence 1985).**Fruit/seed:** Achene 3 mm long, with pappus of hairs 5 mm long, mature mostly July–December. Potential seed set/plant 2000–6000; seed weight without pappus 0.26 mg (Lawrence 1985).**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed. Germination 85% (Lawrence 1985).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC; Qld, Vic., Tas., N.T., S.A., W.A.**Distribution Sydney area:** Coastal, occasionally inland.**Select locations:** Norah Head, Long Bay, Kurnell, Wattamolla, Five Islands, Geringong, Kiama, Glenorie, Yerranderie.**Habitat****Habitat:** Coastal headlands and beaches.**Altitude:** 0–200 m**Annual rainfall:** above 800 mm**Typical local abundance:** Occasional.**Vegetation:** With grasses and herbs, e.g. *Scaevola calandulacea*.**Substrate:** Rocky sea coast, or sand dunes near the sea.**Exposure:****Conservation****Conservation:** Status unknown.

Senecio linearifolius

ASTERACEAE

Life history**Growth form:** Herb or shrub 50–150 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:** Probably less than 1 year (Lawrence 1985).**Flowers:** Yellow, at any time of year. Probably native bee-pollinated, self-incompatible (Lawrence 1985).**Fruit/seed:** Achene 2–2.5 mm long, with pappus of long hairs 5–8 mm long, mature October–June. Potential seed set/plant 10 000–20 000; seed weight without pappus 0.29 mg (Lawrence 1985).**Dispersal, establishment & growth:** Diaspore: fruit. Wind-dispersed, possibly also water-dispersed. Possibly a coloniser species of disturbed sites. Germination 75% (Lawrence 1985).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWS SWS; Vic., Tas.**Distribution Sydney area:** Coast and Blue Mountains.**Select locations:** Gosford, Hornsby, Northbridge, Ingleburn, Bulli, Culoul Range, Bilpin, Katoomba, Kanangra, Robertson, Wingello.**Habitat****Habitat:** Moist forest, disturbed sites?**Altitude:** 0–1000 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Rainforest and moist eucalypt forest, e.g. with *Eucalyptus saligna*, *E. deanei*, *E. fastigata*, *E. radiata*, *E. dalrympleana*.**Substrate:** Clay soils from basalt, shale, occasionally sandstone gullies, fertile–very fertile.**Exposure:****Conservation****Conservation:** Vulnerable in Western Sydney (Benson & McDougall 1991), Conservation status elsewhere unknown.***Senecio macranthus***

ASTERACEAE

Life history**Growth form:** Erect herb mostly 50–100 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:** Probably less than 1 year (Lawrence 1985).**Flowers:** Yellow, August–November. Probably native bee-pollinated, self-incompatible (Lawrence 1985).**Fruit/seed:** Achene 4–5 mm long, with pappus 8–10 mm long, mature September–November. Potential seed set/plant 1000–3000; seed weight without pappus 2.4 mg (Lawrence 1985).**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed. Germination 65% (Lawrence 1985).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC NT CT NWS CWS.**Distribution Sydney area:** Western parts of Blue Mountains.**Select locations:** Yerranderie, Mt Colong, Mt Werong, Killiecrankie Pass, Jenolan Caves, Winburndale, Upper Turon.**Habitat****Habitat:** Moist gullies and hillsides.**Altitude:** 500–1000 m**Annual rainfall:** above 900 mm

Typical local abundance: Frequent.

Vegetation: Eucalypt forest, e.g. with *Eucalyptus rossii*, *E. dives*, *Ficus rubiginosa*, *Acacia falciformis*, also rainforest gullies.

Substrate: Rocky hillsides on soils from shale and basalt, fertile, well-drained.

Exposure:

Conservation

Conservation: Not known.

Senecio madagascariensis *

ASTERACEAE

Fireweed

Life history

Growth form: Herb, 20–60 cm high. Taproot shallow, branching, with numerous fibrous roots within 20 cm of soil surface (Parsons & Cuthbertson 1992).

Vegetative spread: Limited vegetative spread, stems may take root at nodes when in contact with moist soil.

Longevity: 1–2 years. Most plants are winter annuals, top growth dying off during summer and regrowing in autumn but in some situations can perennate (Sindel 1989).

Primary juvenile period: 6–10 weeks (Parsons & Cuthbertson 1992), 20 weeks (P. Kubiak pers. comm.).

Flowers: Yellow, June–October.

Fruit/seed: Achene 2 mm long, with pappus of fine silky white feathery hairs, 6 mm long, mature June–November. Each flower produces 100–150 seeds and one plant may produce 25,000–30,000 seeds (Watson et al. 1984). Growth rate quick.

Dispersal, establishment & growth: Diaspore: fruit. Mainly wind dispersed, close to parent plant (Parsons & Cuthbertson 1992), spread in hay and grain products, on clothing and vehicles and by livestock, birds and other animals (Watson et al. 1983). Soil-stored seedbank (Parsons & Cuthbertson 1992). Non-dormant fraction more than 90 %, stimulated by moisture. Optimum germination occurs between 15°–27° C. At 20° C, 50 % of seed germinated in light while only 8 % germination in the dark; germination can take place over much of the year but most germination is from March–June and plants can produce flowers 6–10 weeks after emergence (Watson et al. 1984). Young seedlings are more sensitive to frost than older plants (Sindel & Michael 1980).

Fire response: Killed; flowering within 15 weeks and fruiting within 20 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.). Spreads into bushland following fire (R. Buchanan pers. comm.). Not clear whether recruitment is from pre- or post-fire seed dispersal.

Interaction with other organisms: Toxic to livestock (cattle and horses) if eaten (Sindel & Michael 1992), but palatable to sheep and goats (Watson et al. 1984). Host to beetle *Chalcolampra* sp., Magpie Moth *Nyctemera amica*, Blue Stem Borer *Patagoniodes farinaria*, leaf and stem mining flies, and two species of flower head feeding flies (Tanner 1993).

Distribution

Status/origin: Naturalised exotic, native to S Africa and Madagascar. First recorded in the Hunter Valley 1918 (Parsons & Cuthbertson 1992).

Botanical subregions: NC CC SC NT CT CWS SWS; Qld.

Distribution Sydney area: Gosford, northern Sydney, Cumberland Plain, Western Sydney & Orange area.

Select locations: Wyong Creek (1954), Pennant Hills, Kurmond, Kellyville, Windsor (M. Clarke pers. comm.), Casula (1967), Campbelltown, Molong, Robertson (P. Kodela pers. comm.).

Habitat

Habitat: Heavily grazed pastures, cultivated land, roadsides and wasteland

Altitude: 0–1100 m **Annual rainfall:** above 600 mm

Typical local abundance: Frequent–dominant.

Vegetation: Exotic pastures, weedy herbaceous vegetation. Ground stratum.

Substrate: Sandy to clay soil from shales and sandstones. Soil fertile. Watertable mostly low, moisture supply intermittent, fresh.

Exposure: Indifferent–sheltered sites; light–no shade.

Conservation

Conservation: Spread in Sydney area mainly since 1960s. Not generally found in bushland areas but an agricultural weed in heavily grazed or neglected pastures and on cultivated or

disturbed ground during autumn–spring (Watson et al. 1984). Best control is to encourage competing pasture species. Declared noxious weed in some shires in NSW. Spreads into bushland following fire (R. Buchanan pers. comm.).

Senecio minimus

ASTERACEAE

Life history

Growth form: Erect herb, 20–100 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: October–March.

Fruit/seed: Achene 2 mm long, with pappus 4–5 mm long.

Dispersal, establishment & growth: Diaspore: fruit. Wind dispersed (Westoby et al. 1990).

Probably quick growing coloniser species.

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC SC CC NT CT ST; Qld, Vi c, Tas., S.A., W.A., N.Z.

Distribution Sydney area: Mainly coastal, widespread.

Select locations: Mooney Mooney, Dural, Lane Cove, Otford, Mt Kembla, Bilpin, Ingleburn, Douglas Park, Razorback, Thirlmere Lakes, Mittagong.

Habitat

Habitat: Moist places, gullies, roadsides.

Altitude: 0–700 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent.

Vegetation: Eucalypt forest, e.g. with *Eucalyptus pilularis*, *Syncarpia glomulifera* and margin of rainforest, also riverbanks, e.g. with *Viminaria juncea*, *Phragmites australis*.

Substrate: Clay loam from shale to organic soils, fertile. Watertable high to low, periodically waterlogged.

Exposure: Shaded sites.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).

Senecio pterophorus *

ASTERACEAE

Life history

Growth form: Erect shrub mostly 80–150 cm high.

Vegetative spread:

Longevity: Perennial (Lawrence 1985).

Primary juvenile period: Probably less than 1 year (Lawrence 1985).

Flowers: Yellow, January–March. Probably native bee-pollinated, self-incompatible (Lawrence 1985).

Fruit/seed: Achene 2 mm long, with pappus of hairs 5 mm long. Potential seed set/plant 20 000–30 000; seed weight without pappus 0.17 mg (Lawrence 1985).

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed. Germination 80% (Lawrence 1985).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S Africa. Recently reported as a naturalised.

Botanical subregions: CC; Vic., S.A.

Distribution Sydney area: Western Sydney — a recently reported weed.

Select locations: Doonside (1989), Mt Druitt (1990), Kurmond (1990).

Habitat

Habitat: Remnant bush.

Altitude: 0–200 m

Annual rainfall: 700–900 mm

Typical local abundance: Frequent.

Vegetation: Remnant bush, e.g. *Eucalyptus tereticornis*–*E. crebra* woodland. Mid-stratum.

Substrate: Clay soil from Wianamatta Shale, fertile. Watertable mostly low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Only recently reported as a naturalised species but its occurrence in remnant bushland areas in western Sydney suggests that it may be a potential bushland weed species.

Senecio quadridentatus

ASTERACEAE

Cotton Fireweed

Life history

Growth form: Herb to about 40–100 cm high.

Vegetative spread: No.

Longevity: Annual or biennial (Purdie 1977).

Primary juvenile period: Probably less than 1 year (Lawrence 1985).

Flowers: October–March. Probably native bee-pollinated, self-compatible (Lawrence 1985).

Fruit/seed: Achene 3–4 mm long with pappus of hairs 5–7 mm long, mature October–March. Potential seed set/plant 15 000–30 000; seed weight without pappus 0.15 mg (Lawrence 1985).

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Recruitment fire-related (Harden 1992). Germination 95% (Lawrence 1985).

Fire response: Seedlings recorded less than 1 year after fire (Purdie 1977).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT ST CWS SWS NWP; Vic.

Distribution Sydney area: Western Sydney, Bathurst.

Select locations: Denistone, Marayong, Glenfield, Grose Vale, Razorback, Thirlmere, Linden, Medlow Bath, Capertee, Bathurst, Wildes Meadow (P. Kodela pers. comm.).

Habitat

Habitat: Ephemeral watercourses, roadsides, disturbed sites.

Altitude: 0–1000 m

Annual rainfall: 700–1200 mm

Typical local abundance: Frequent–occasional.

Vegetation: Eucalypt woodland, e.g. with *Eucalyptus moluccana*, *E. polyanthemos*, *E. macrorhyncha*.

Substrate: Generally clay soils from Wianamatta Shale, also granite and limestone, fertile soil. Watertable mostly low.

Exposure: Light shade–full sun.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), status elsewhere unknown.

Senecio species *E*

ASTERACEAE

Life history

Growth form: Erect herb 20–80 cm high. (Reported as annual at Culoul Range in 1981.)

Vegetative spread:

Longevity: Probably relatively short-lived.

Primary juvenile period:

Flowers: September–March.

Fruit/seed: Achene 3–4 mm long, with pappus 6–7 mm long.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response:

Interaction with other organisms:**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC NT CT ST CWS SWS; Vic., Tas., W.A.**Distribution Sydney area:** Mainly upper Blue Mountains but widespread.**Select locations:** Culoul Range, Tuggerah, Bobbin Head, Kentlyn, Thirlmere Lakes, Medlow Bath, Wolgan Valley, Sunny Corner, Moss Vale.**Habitat****Habitat:** Eucalypt woodland, possibly disturbed sites.**Altitude:** 0–1200 mm **Annual rainfall:** above 900 mm**Typical local abundance:** Occasional.**Vegetation:** Eucalypt forest, e.g. with *Eucalyptus punctata*, *E. beyeriana*, *Syncarpia glomulifera* and woodland, e.g. with *Eucalyptus mannifera*.**Substrate:** Sandy loam, e.g. from shale enriched sandstone, well-drained–poorly drained, infertile.**Exposure:****Conservation****Conservation:** Rare in coastal areas, conservation status unknown.***Senecio tamioides* *****ASTERACEAE****Life history****Growth form:** Scrambling herb.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Yellow, winter.**Fruit/seed:** Achene 2 mm long, with pappus 6–7 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to S Africa. Introduced as ornamental, occasionally naturalised.**Botanical subregions:** CC; Qld.**Distribution Sydney area:** Northern Sydney suburbs.**Select locations:** Narrabeen (1917), Pennant Hills (1921).**Habitat****Habitat:****Altitude:** 0–100 m **Annual rainfall:** above 1200 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Occasionally naturalised in moist gullies in Sydney area.***Senecio tenuiflorus*****ASTERACEAE****Life history****Growth form:** Herb, usually 30–80 cm high.**Vegetative spread:** No.**Longevity:** Less than 2 years.**Primary juvenile period:****Flowers:** Spring–summer.**Fruit/seed:** Achene 2.5 mm long, with pappus 6–8 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CT; Qld, Vic., Tas., S.A.

Distribution Sydney area: Western Blue Mountains.

Select locations: Blackheath (1899), Jenolan Caves (1899), Gibraltar Rocks Trail.

Habitat

Habitat: Dispersed sites, open woodland.

Altitude: 800–1000 m **Annual rainfall:** 900–1200 mm

Typical local abundance: Occasional.

Vegetation: Woodland, e.g. *Eucalyptus sieberi*–*E. blaxlandii* (Keith & Benson 1988).

Substrate: Well-drained sandy soil on sandstones of shoalhaven group.

Exposure:

Conservation

Conservation: Localised and probably uncommon, conservation status unknown.

Senecio vagus* subsp. *eglandulosus

ASTERACEAE

Life history

Growth form: Herb or shrub 60–120 cm high.

Vegetative spread:

Longevity: ? 2–4 years.

Primary juvenile period: Probably less than 1 year (Lawrence 1985).

Flowers: Yellow, October–January. Probably native bee-pollinated, self-incompatible (Lawrence 1985).

Fruit/seed: Achene 5 mm long, with pappus 7–10 mm long, mature October–January.

Potential seed set/plant 1000–2000; seed weight without pappus 1.92 mg (Lawrence 1985).

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Germination 45% (Lawrence 1985).

Fire response: Killed, seedlings grow vigorously after fire.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC NT CT; Qld.

Distribution Sydney area: Coast, and Blue Mountains.

Select locations: Avoca, Narrabeen, Ingleburn, Stanwell Park, Wallacia, Bargo, Blackheath, Jamieson Valley.

Habitat

Habitat: Moist gullies, creekbanks, headlands.

Altitude: 0–1000 m **Annual rainfall:** above 800 mm

Typical local abundance: Occasional.

Vegetation: Chiefly rainforest or eucalypt forest, high rainfall.

Substrate: Med-high nutrient soils, from sandstone or alluvium.

Exposure: Mid-shade.

Conservation

Conservation: Bargo is southern limit. Vulnerable in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.

Senecio velleioides

ASTERACEAE

Life history

Growth form: Herb or shrub 30–130 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:** Probably less than 1 year (Lawrence 1985).**Flowers:** Yellow, October–May. Probably native bee-pollinated, self-incompatible (Lawrence 1985).**Fruit/seed:** Achene 2.5 mm long, with pappus 5–8 mm long. Potential seed set/plant 2000–5000; seed weight without pappus 0.54 mg (Lawrence 1985).**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed. Germination 35% (Lawrence 1985).**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC NT CT ST CWS; Vic., Tas.**Distribution Sydney area:** Mainly Blue Mountains and Southern Highlands.**Select locations:** Ourimbah SF, Thirlmere Lakes, Bargo, Macquarie Pass, Mt Kerry, Mt Cameron, Mt Victoria, Kangaloon, Fitzroy Falls, Wingello.

Habitat

Habitat: Moist Eucalypt forest.**Altitude:** 0–1100 m**Annual rainfall:** above 900 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Eucalypt forest, e.g. with *Eucalyptus gummifera* or more moist forest, e.g. with *Eucalyptus smithii*, *E. quadrangulata* (Fallding & Benson 1985).**Substrate:** Sandy soils from sandstone, occasionally on basalt.**Exposure:**

Conservation

Conservation: Status unknown.*Senecio vulgaris* *

ASTERACEAE

Groundsel

Life history

Growth form: Erect herb 10–50 cm high.**Vegetative spread:****Longevity:** Annual or overwintering (Ciba-Geigy 1968–).**Primary juvenile period:****Flowers:** Pale yellow, throughout the year, usually self-pollinated, rarely insect-pollinated (Ciba-Geigy 1968–).**Fruit/seed:** Achene 2 mm long, with pappus 5–7 mm long.**Dispersal, establishment & growth:** Dispersed by wind, water, animals and humans; germinates throughout the year, often 2 or more generations in one year (Ciba-Geigy 1968–).**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Naturalised exotic, native to Europe.**Botanical subregions:** CC CT ST; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:****Select locations:** Specimens unavailable.

Habitat

Habitat:**Altitude:****Annual rainfall:****Typical local abundance:****Vegetation:****Substrate:** Soils rich in nutrients, nitrogen indicator (Ciba-Geigy 1968–).**Exposure:** Disappears in closed stands for want of light (Ciba-Geigy 1968–).

Conservation

Conservation:

Sigesbeckia orientalis* subsp. *orientalis

ASTERACEAE

Indian Weed

Life history**Growth form:** Erect herb to 80 cm high.**Vegetative spread:** No.**Longevity:** Short-lived.**Primary juvenile period:** Less than 1 year.**Flowers:** Yellow, January–May, peak March–April, flowerheads surrounded by sticky, glandular bracts.**Fruit/seed:** Achene 2–3 mm long; mature March–June.**Dispersal, establishment & growth:** Diaspore: fruit, no special seed dispersal morphology (Westoby et al. 1990), but fruit-head possibly dispersed by attachment as well as individual achenes dispersed by attachment (L.McD.). Coloniser of disturbed sites.**Fire response:** Killed, germinates vigorously from soil-stored seed immediately after fire, even in absence of rain. Grew to 30 cm high and flowered in 4 months at Culoul Range in 1980 drought after fire. Killed by high-intensity fire (1/1994) at Lane Cove, seedlings flowered within 11 weeks, fruiting within 16 weeks (P. Kubiak pers. comm.).**Interaction with other organisms:** Seeds eaten by White-browed Scrubwren *Sericornis frontalis* (Barker & Vestjens 1989, 1990). Contains a saponin, used medicinally in Asia and Polynesia (Cambie & Ash 1994).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT ST NWP SWP; Qld, Vic., Tas., N.T., S.A., W.A., Asia, Africa.**Distribution Sydney area:** Widespread.**Select locations:** Watagan Mountains, Hornsby, Waterfall, Albion Park, Bomaderry, Grose Vale, Springwood, Goodmans Ford, Mount Wilson, Robertson.**Habitat****Habitat:** Deep valleys, creeks, roadsides.**Altitude:** 0–1000 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Margins of rainforest; open areas in tall forest, e.g. with *Eucalyptus pilularis*, *E. paniculata*, woodland, e.g. with *Angophora floribunda*.**Substrate:** Fertile soils, from limestones, slate, volcanic necks, or sandy alluvium, often disturbed sites, one record indicates 'weed of cultivation'. Basalt (P. Kodela pers. comm.).**Exposure:** Mid-shade.**Conservation****Conservation:** Conserved in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.***Silybum marianum* ***

ASTERACEAE

Variegated Thistle

Life history**Growth form:** Herb to 2.5 m high.**Vegetative spread:** No.**Longevity:** 2 years.**Primary juvenile period:****Flowers:** Purple, September–December.**Fruit/seed:** Achene 6–8 mm long, with pappus of bristles 15–20 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:** Poisonous to stock. Seed eaten by Galah *Cacatua roseicapilla* (Lepschi 1993).**Distribution****Status/origin:** Naturalised exotic, native to S Europe & N. Africa.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:** Widespread.

Select locations: Warwick Farm, Liverpool (1909), Doonside, Mt Annan, Berry, Mt Cameron, Orange, Robertson (P. Kodela pers. comm.).

Habitat

Habitat: Stockyards, paddocks, pastures.

Altitude: 0–1000 m **Annual rainfall:** 700–1000 mm

Typical local abundance: Occasional.

Vegetation: Cultivated paddocks. Grazed pastures (P. Kodela pers. comm.).

Substrate: Clay soils from Wianamatta Shale, basalt, fertile, well drained. Recorded on saline sites in western NSW (Semple 1993).

Exposure:

Conservation

Conservation: Widespread weed.

Solenogyne bellioides* (Lagenifera bellioides)*ASTERACEAE****Life history**

Growth form: Herb 5–18 cm high, with radical leaves and fleshy roots; rhizome short, vertical.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: White–bluish, spring–summer.

Fruit/seed: Achene 2 mm long, no pappus. Mature October–May, peak April.

Dispersal, establishment & growth: Diaspore: fruit. Springs up after summer rain (Blakely, Herbarium note).

Fire response: Probably resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT NWS CWS SWP; Qld.

Distribution Sydney area: Widespread — lower elevations.

Select locations: Mt Wareng, Cheltenham, Concord, Blackett, Ingleburn, Menangle, Thirlmere, Glanmire, Butlers Swamp (P. Kodela pers. comm.), Goodmans Ford.

Habitat

Habitat: Low growing grassy sites, often subject to some disturbance.

Altitude: 0–700 m **Annual rainfall:** above 800 mm

Typical local abundance: Frequent.

Vegetation: Low-growing grassland, e.g. burnt, compacted soil, between bricks in footpath. Sedgeland (P. Kodela pers. comm.). Understorey in woodland.

Substrate: Clay soils from Wianamatta Shale, also granite. Soil fertile. Watertable permanently low, moisture supply intermittent, fresh.

Exposure: Indifferent to exposure, light shade–full sun.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.

Solenogyne dominii* (Lagenifera sp. B)*ASTERACEAE****Life history**

Growth form: Herb 1.5–10 cm high; rhizome short, vertical, roots fleshy.

Vegetative spread: No.

Longevity: Perennial.

Primary juvenile period:

Flowers: Magenta-tinged.

Fruit/seed: Achene 2 long, no pappus, mature October–May, peak March.

Dispersal, establishment & growth: Diaspore: fruit.

Fire response:**Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC NT CT ST CWS SWS; Vic.**Distribution Sydney area:** Coast and western Blue Mountains.**Select locations:** Hurstville (1899), Ryde, Albion Park, Goodmans Ford, Turondale, Glanmire.**Habitat****Habitat:****Altitude:** 0–700 m**Annual rainfall:** 600–1200 mm**Typical local abundance:** Frequent.**Vegetation:** Woodland, e.g. with *Eucalyptus melliodora*, *E. albens*. Ground stratum.**Substrate:** Granite, slate. Fertile–infertile. Watertable permanently low, moisture supply intermittent, fresh.**Exposure:****Conservation****Conservation:** Conservation status unknown.***Solenogyne gunnii*** (Lagenifera sp. A var. B)**ASTERACEAE****Life history****Growth form:** Herb to 11 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Magenta-tinged, November–March.**Fruit/seed:** Achene 2–3 mm long, no pappus, mature January–May.**Dispersal, establishment & growth:** Diaspore: fruit.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NT CT ST; Vic., Tas.**Distribution Sydney area:** Western Blue Mountains, Southern Highlands.**Select locations:** Lidsdale, Hartley, Orange, Oberon, Abercrombie Caves, Wingecarribee Swamp.**Habitat****Habitat:** Grassland. Swamp margins.**Altitude:** 500–1000 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Frequent–rare.**Vegetation:** Grassland with *Brachycome*, *Plantago varia* etc. Ground stratum; sedgeland/pasture ecotone area (P. Kodela pers. comm.).**Substrate:** Sandy loam or on metamorphic rock. Infertile soil or more fertile peaty soil (P. Kodela pers. comm.). Watertable permanently low, moisture supply intermittent, fresh.**Exposure:** Full sun.**Conservation****Conservation:*****Solidago canadensis* var. *scabra* *****ASTERACEAE**

Goldenrod

Life history**Growth form:** Herb 0.8–2 m high with stolons and rhizomes.**Vegetative spread:** Spreads by stolons up to several metres.**Longevity:** Indefinite.

Primary juvenile period:**Flowers:** Yellow, summer.**Fruit/seed:** Achene 1–2 mm long, with pappus of bristles 2–3 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed, though establishment mainly result of human dispersal of stolons, e.g. dumping garden waste.**Fire response:** Resprouted from base, flowering within 16 weeks and fruiting within 19 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).**Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to N America; introduced for horticulture, localised garden escape.**Botanical subregions:** NC CC NT CWS; Qld, S.A.**Distribution Sydney area:** Suburban areas.**Select locations:** Wyong (1961), Roseville, Maroota, Blacktown, Casula, Minto, Campbelltown.**Habitat****Habitat:** Roadsides and disturbed sites near habitation.**Altitude:** 0–200 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent.**Vegetation:** Disturbed sites.**Substrate:** Disturbed sites on sandstone, shale. Soil fertile–infertile. Watertable permanently low, moisture supply intermittent, fresh.**Exposure:** Full sun.**Conservation****Conservation:** Localised garden escape, spreads vegetatively in limited areas.***Soliva anthemifolia* *****ASTERACEAE**

Dwarf Jo-jo, Button Weed

Life history**Growth form:** Small, diffuse, prostrate, stemless herb with radical leaves.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** June–March, peak November.**Fruit/seed:** Achene 3 mm long, with 2–3 mm spine.**Dispersal, establishment & growth:** Diaspore: fruit, burr, animal-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to S America.**Botanical subregions:** NC CC SC NWS NWP SWP; Qld, Vic., S.A.**Distribution Sydney area:** Mainly suburban areas.**Select locations:** Sydney (1805), Cheltenham, Penshurst, Glenfield, Richmond, Camden, Albion Park.**Habitat****Habitat:** Weed of lawns and playing fields.**Altitude:** 0–200 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Grasslands, crops, pastures, lawns.**Substrate:** Sandy and clay soils.**Exposure:****Conservation****Conservation:** Weed of lawns and playing fields.

***Soliva sessilis* *** (*Soliva pterosperma*)

ASTERACEAE

Jo-jo, Bindyi, Lawn Burweed

Life history

Growth form: Small, diffuse, prostrate, stemless herb; leaves radical, branches stolon-like.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Pale greenish-yellow, August–December.

Fruit/seed: Achene 3–4 mm long, with wings and spine 3 mm long, forming a burr. Mature August–December.

Dispersal, establishment & growth: Diaspore: burr, animal-dispersed, including human feet. Seed germinates in winter, plant dies in summer unless irrigated (Commens et al. 1982).

Fire response:

Interaction with other organisms: May cause dermatitis of knees, soles of feet, and arms in humans (Commens et al. 1982).

Distribution

Status/origin: Naturalised exotic, native to S America. First identified on the hill of Sydney Cricket Ground in 1890s (Commens et al. 1982).

Botanical subregions: NC CC SC ST NWS CWS SWS Vic.

Distribution Sydney area: Mainly coastal areas.

Select locations: Woy Woy, Pennant Hills, Moore Park (1899), Cabarita, Glenfield, Dural, Windsor, Albion Park, Kangaroo Valley.

Habitat

Habitat: Weed of lawns, disturbed sites.

Altitude: 0–200 m **Annual rainfall:** above 800 mm

Typical local abundance: Frequent.

Vegetation: Lawns.

Substrate: Sandy soils, infertile, well-drained.

Exposure: Full sun.

Conservation

Conservation: Nuisance weed of lawns.

***Sonchus asper* subsp. *glaucescens* ***

ASTERACEAE

Prickly Sowthistle

Life history

Growth form: Herb, 20–150 cm high, with woody taproot.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period: Less than 2 years.

Flowers: Yellow, October–December. Insect-pollinated (Ciba-Geigy 1968–).

Fruit/seed: Achene 2–3 mm long, with pappus 8 mm long.

Dispersal, establishment & growth: Diaspore: fruit, dispersed by wind, water, animals and humans; moderate to vigorous competitor for space and nutrients (Ciba-Geigy 1968–).

Fire response: Seedlings recorded less than 1 year after fire (Purdie 1977).

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: NC CC SC NT CT ST CWS SWS SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Colo (1911), Woy Woy (1912), Liverpool, Richmond, Mt Annan, Mt Tomah, Blackheath, Hartley, Robertson (P. Kodela pers. comm.).

Habitat

Habitat: Weed of roadsides, cultivation, gardens and wasteland.

Altitude: 0–1000 m **Annual rainfall:** above 700 mm

Typical local abundance: Occasional.

Vegetation: Wasteland weeds.

Substrate: Clay soils from shale and basalt, fertile.

Exposure: Full sun.

Conservation

Conservation: Weed of disturbed sites, not invasive of bush.

Sonchus hydrophilus

ASTERACEAE

Native Sowthistle

Life history

Growth form: Herb 50–120 cm high, with woody taproot.

Vegetative spread: No.

Longevity: 1–3 years.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, at any time, probably insect-pollinated.

Fruit/seed: Achene 4 mm long, with pappus 8 mm long.

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC; Qld, S.A., N.G.

Distribution Sydney area: Coast south from Sydney.

Select locations: Cronulla (1816), Gerringong (1928).

Habitat

Habitat: Sea shore cliffs and rocky headlands.

Altitude: 0–50 m

Annual rainfall: above 1200 mm

Typical local abundance:

Vegetation:

Substrate: Temporarily wet ground.

Exposure:

Conservation

Conservation: Uncommon.

Sonchus oleraceus *

ASTERACEAE

Common Sowthistle

Life history

Growth form: Herb 30–110 cm high with taproot and fibrous roots.

Vegetative spread: No

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, most of the year. Insect-pollinated (Ciba-Geigy 1968–).

Fruit/seed: Achene 3–4 cm long, with pappus 5–8 mm long, mature March–November.

Dispersal, establishment & growth: Diaspore: fruit; animal, water, and wind-dispersed (Carr et al. 1992).

Fire response: Killed after medium to high-intensity fire, flowering and fruiting within 15 weeks of high-intensity fire (1/1994) at Lane Cove, seedlings observed (P. Kubiak pers. comm.).

Interaction with other organisms: Foodplant of Grey Teal *Anas gibberifrons* (Barker & Vestjens 1989,1990). Eaten by rabbits (R. Buchanan pers. comm.). Used as green feed for caged birds.

Distribution

Status/origin: Naturalised exotic, native to Europe. Formerly used in folk medicine and as a salad (Ciba-Geigy 1968–).

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Cheltenham, Dural, Balgowlah, Centennial Park (1901), Casula, Liverpool, Hilltop, Minnamurra, Robertson (P. Kodela pers. comm.), Cambewarra.

	Habitat
Habitat: Wetlands, gardens, mechanically disturbed places, roadsides.	
Altitude: 0–800 m	Annual rainfall: above 700 m
Typical local abundance: Occasional.	
Vegetation: Disturbed woodland, wetlands.	
Substrate: Clay soils from Wianamatta Shale or moist sandy alluvium, fertile. Recorded on saline sites in western NSW (Semple 1993). Soils rich in nitrogen (Ciba-Geigy 1968–).	
Exposure: Light shade–full sun.	
	Conservation
Conservation: Widespread weed of cultivation, pastures and disturbed areas but not invasive of bushland except after fires. A minor invader of bushland after fire of any intensity, especially near edges (R. Buchanan pers. comm.).	

Stemmacantha australis (*Leuzea australis*, *Centaurea australis*)

ASTERACEAE

	Life history
Growth form: Erect herb to 60 cm high, branches slightly woolly.	
Vegetative spread:	
Longevity: Perennial.	
Primary juvenile period:	
Flowers: Purplish, spring–autumn.	
Fruit/seed: Achene 8 mm long, with pappus 20 mm long.	
Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed.	
Fire response:	
Interaction with other organisms:	
	Distribution
Status/origin: Native.	
Botanical subregions: CT ?NWP; Qld, Vic.	
Distribution Sydney area: Jenolan Caves.	
Select locations: Jenolan Caves (1899), only Sydney record.	

	Habitat
Habitat:	
Altitude: 800 m	Annual rainfall: 1000 mm
Typical local abundance:	
Vegetation:	
Substrate: Heavy soils.	
Exposure:	
	Conservation
Conservation: Probably very rare or extinct in Sydney area, conservation status unknown.	

Stuartina muelleri

ASTERACEAE

Spoon Cudweed

	Life history
Growth form: Herb 2–12 cm high.	
Vegetative spread:	
Longevity:	
Primary juvenile period:	
Flowers: Greenish, spring.	
Fruit/seed: Achene 0.5–1 mm long, no pappus.	
Dispersal, establishment & growth: Diaspore: fruit.	
Fire response:	
Interaction with other organisms:	
	Distribution
Status/origin: Native.	
Botanical subregions: CT ST NWS CWS SWS NWP SWP NFWP; Vic., S.A., W.A.	
Distribution Sydney area: Abercrombie Caves.	

Select locations: Abercrombie Caves (1951).

Habitat

Habitat:

Altitude: 600 m

Annual rainfall: 600 mm

Typical local abundance:

Vegetation: Grassland, woodland and sclerophyll forest.

Substrate: Rocky hillsides.

Exposure:

Conservation

Conservation: Widespread in inland districts. Eastern limit is Abercrombie Caves, conservation status unknown.

Tagetes minuta *

ASTERACEAE

Stinking Roger

Life history

Growth form: Strongly aromatic herb 1–2 m high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, February–May.

Fruit/seed: Achene 5–8 mm long, with pappus of scales 3 mm long.

Dispersal, establishment & growth: Diaspore: fruit, probably animal-dispersed.

Fire response: Probably killed, flowering and fruiting within 20 weeks of high-intensity fire at Narrabeen (1/1994) (P. Kubiak pers. comm.). Dense stands along roadsides near Narrabeen Lakes and Ingleside after high-intensity fire (1/1994) (L.McD.), probably from soil-stored seed.

Interaction with other organisms: Contains a volatile oil with tagetone; reported to have an irritant effect on eyes and skin and cause contact dermatitis; taints dairy products if eaten by cows, and suspected of poisoning stock (Hurst 1942).

Distribution

Status/origin: Naturalised exotic, native to S America.

Botanical subregions: NC CC SC NT NWS CWS SWP NFWP; Qld, S.A., W.A.

Distribution Sydney area: Mainly coastal.

Select locations: Kincumber, Avalon, Hornsby, Forestville (L.McD.), Sydney (1893), Kurrajong, Doonside, Picton, Bulli, Wollongong, Kiama, Berry.

Habitat

Habitat: Roadsides, riverbanks.

Altitude: 0–100 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent–dominant.

Vegetation: With weeds, e.g. *Bidens pilosa*, *Sida rhombifolia*.

Substrate: Alluvial and clay soils, fertile, watertable mostly low.

Exposure: Mid shade–full sun.

Conservation

Conservation: Weed of disturbed sites.

Tanacetum parthenium *

ASTERACEAE

Feverfew

Life history

Growth form: Erect, aromatic herb to 60 cm high, with rhizome.

Vegetative spread: No.

Longevity: About 5 years.

Primary juvenile period: Less than 1 year.

Flowers: White, disc yellow, spring–summer.

Fruit/seed: Achene 1.5 mm long, with minute pappus.

Dispersal, establishment & growth: Diaspore: fruit, ligule persistent for long enough to aid wind-dispersal?

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe, introduced as garden ornamental, rarely naturalised.

Botanical subregions: CT ST CWS; Vic., Tas., S.A.

Distribution Sydney area:

Select locations: Campbelltown (1963).

Habitat

Habitat: Gardens, roadsides, wasteland.

Altitude: 0–100 m **Annual rainfall:** above 700 mm

Typical local abundance: Rare.

Vegetation:

Substrate: Clay soils.

Exposure:

Conservation

Conservation: Occasionally naturalised on roadsides and as a garden weed.

***Tanacetum vulgare* ***

ASTERACEAE

Tansy

Life history

Growth form: Erect, aromatic herb to 1.2 m high, with rhizome.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, spring–autumn.

Fruit/seed: Achene 1–2 mm long, with minute pappus.

Dispersal, establishment & growth: Diaspore: fruit. Ligula appears to be persistent for long enough to aid wind-dispersal.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe, sporadic garden escape.

Botanical subregions: CC SC NT CT ST NWS NWP; Qld, Vic., Tas., S.A.

Distribution Sydney area: Coast, western Blue Mountains, Southern Highlands.

Select locations: Cheltenham, Leichhardt, Otford, Nowra, Mt Wilson (1896), Bowenfels, Bathurst, Bowral, Kangaloon (P. Kodela pers. comm.), Bundanoon.

Habitat

Habitat: Roadsides and vacant land.

Altitude: 0–1000 m **Annual rainfall:** above 800 mm

Typical local abundance: Frequent–occasional.

Vegetation: Grassy areas.

Substrate: Clay soils.

Exposure: Full sun.

Conservation

Conservation: Naturalised along roadsides, probably not invasive of bush.

***Taraxacum officinale* ***

ASTERACEAE

Dandelion

Life history

Growth form: Herb 5–40 cm high, with radical leaves.

Vegetative spread: No.

Longevity: Perennial.

Primary juvenile period:

Flowers: Yellow, most of the year.

Fruit/seed: Achene 2.5–4.5 mm long, with pappus of bristles 6 mm long.

Dispersal, establishment & growth: Diaspore: fruit. Wind-dispersed many kilometres (Buchanan 1989).

Fire response: Probably resprouted, flowering within 11 weeks and fruiting within 25 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).

Interaction with other organisms: Palatable to rabbits (Leigh et al. 1987). Foodplant of moth caterpillars *Amata* sp., *Xanthorhoe vicissata* and *Spilosoma glatignyi* (Coupar & Coupar 1992). Medicinal properties — used in Europe and in Australia, late 1800s.

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: NC CC SC NT CT ST NWS SWS NWP SWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Balgowlah, Ermington, Kurnell, Cabarita, Casula, Campbelltown, Mt Kembla (1891), Jenolan Caves (1886), Moss Vale.

Habitat

Habitat: Lawns, roadsides, wasteland and in cultivated and pasture areas.

Altitude: 0–1000 m **Annual rainfall:** above 700 mm

Typical local abundance: Occasional.

Vegetation: Gardens, lawns.

Substrate: Clay soils, fill, moderate nutrients. Recorded on saline sites in western NSW (Semple 1993).

Exposure: Light shade–full sun (R. Buchanan pers. comm.).

Conservation

Conservation: Minor weed. Rarely invades bushland (R. Buchanan pers. comm.).

Tolpis umbellata *

ASTERACEAE

Yellow Hawkweed

Life history

Growth form: Herb to 40 cm high

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, rarely purple, November–March.

Fruit/seed: Achene 1–2 mm long, with hairs.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Mediterranean region, America, S Africa.

Botanical subregions: CC NT CT ST NWS CWS SWS; Vic., S.A.

Distribution Sydney area: Western Sydney and Bathurst–Blayney.

Select locations: Mt Colah, Minto, Castle Hill, Richmond (1910), Marrangaroo, Glanmire, Blayney (1899).

Habitat

Habitat: Grassland, woodland.

Altitude: 0–1000 m **Annual rainfall:** above 800 mm

Typical local abundance: Frequent–occasional.

Vegetation: Grassland, woodland.

Substrate: Heavy clay soils.

Exposure:

Conservation

Conservation: Occasionally naturalised, not invasive of bushland.

***Tragopogon porrifolius* ***

ASTERACEAE

Salsify

Life history**Growth form:** Herb to 1.2 m high with long taproot.**Vegetative spread:** No.**Longevity:** 2 years.**Primary juvenile period:** 2 years.**Flowers:** Pale-deep purple, October–Jan.**Fruit/seed:** Achene 10–15 mm long, with plumose pappus, 15–25 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind and probably animal-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe, Asia. Introduced as root vegetable plant, occasionally naturalised.**Botanical subregions:** CC NT CT ST NWS CWS SWS SWP NFWP; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:** Western Sydney, Tablelands.**Select locations:** Blacktown, Revesby, Emu Plains, Liverpool, Mt Annan, Menangle (1893), Orange, Miittingong, Moss Vale.**Habitat****Habitat:** Roadsides, grassland and wasteland.**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Wasteland weeds, e.g. *Echium*, *Papaver somniferum* and pasture grasses.**Substrate:** Clay soils. Recorded on saline sites in western NSW (Semple 1993).**Exposure:****Conservation****Conservation:** Occasionally naturalised in rural areas.***Tripleurospermum inodorum* * (Matricaria perforata)**

ASTERACEAE

Scentless Mayweed

Life history**Growth form:** Herb 15–100 cm high.**Vegetative spread:** No.**Longevity:** 2 years.**Primary juvenile period:** 2 years.**Flowers:** White, disc yellow, spring–summer. Insect-pollinated (Ciba-Geigy 1968–).**Fruit/seed:** Achene 2 mm long, with small pappus.**Dispersal, establishment & growth:** Diaspore: fruits dispersed by wind, water, animals, and humans (with cereals and seed); moderate–vigorous competitor for space and user of nitrogen (Ciba-Geigy 1968–).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe and Asia. Distribution world-wide (Ciba-Geigy 1968–).**Botanical subregions:** CC NT CWS; Tas.**Distribution Sydney area:** Ryde.**Select locations:** Ryde TAFE (1966) only Sydney record.**Habitat****Habitat:** Roadsides, and waste places.**Altitude:** 200 m**Annual rainfall:** 1000 mm**Typical local abundance:** Occasional.**Vegetation:****Substrate:** Nitrogenous soil (Ciba-Geigy 1968–).**Exposure:****Conservation****Conservation:** Uncommon in Sydney area.

Triptilodiscus pygmaeus (Helipterum australe)

ASTERACEAE

Life history

Growth form: Herb to 8 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Yellow, Sept–Nov.**Fruit/seed:** Achene 2 mm long, with plumed pappus of 3–4 bristles.**Dispersal, establishment & growth:** Diaspore: fruit, probably wind-dispersed.**Fire response:** Probably killed.**Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic., S.A., W.A.**Distribution Sydney area:** Mainly western Sydney and western Blue Mountains.**Select locations:** Hornsby, Auburn, Newington, Leumeah, Vineyard, Richmond, Menangle Park, Hartley Vale, Winburndale, Abercrombie Caves.

Habitat

Habitat: Grasslands.**Altitude:** 0–700 m**Annual rainfall:** 600–1200 mm**Typical local abundance:** Occasional.**Vegetation:** Grasslands and woodlands.**Substrate:** Clay soils, sometimes bare areas, wet places, infertile soils.**Exposure:**

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991).*Vellereophyton dealbatum* * (Gnaphalium candidissimum)

ASTERACEAE

White Cudweed

Life history

Growth form: Herb to 50 cm high.**Vegetative spread:** No.**Longevity:** 1–2 years.**Primary juvenile period:** 1 year.**Flowers:** Yellow, October–December.**Fruit/seed:** Achene 0.4 mm long, with pappus of bristles 1.5 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Naturalised exotic, native to S Africa.**Botanical subregions:** CC; Vic., S.A., Tas.**Distribution Sydney area:** Mainly Maroubra–La Perouse.**Select locations:** Maroubra Bay (1959), Malabar, Little Bay, La Perouse, Rookwood Cemetery.

Habitat

Habitat: Disturbed moist sites.**Altitude:** 0–100 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Frequent.**Vegetation:** Margins of swamp.**Substrate:** Wet sandy or clay soils, in depressions, disturbed sites.**Exposure:**

Conservation

Conservation: Locally naturalised exotic, probably still spreading.

***Verbesina encelioides* subsp. *encelioides* ***

ASTERACEAE

Crownbeard

Life history

Growth form: Herb to 60 cm high, shallow-rooted.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: Yellow, January–April.

Fruit/seed: Achene 5–8 mm long, with pappus of bristles 1–2 mm long (obscured by wings).

Dispersal, establishment & growth: Diaspore: fruit, probably wind-dispersed and/or water-dispersed. Seasonally and locally abundant.

Fire response:

Interaction with other organisms: Poisonous to stock if eaten.

Distribution

Status/origin: Naturalised exotic, native to America.

Botanical subregions: NC CC ST NWS CWS SWS NWP SWP NFWP; Qld, Vic., N.T., S.A.

Distribution Sydney area: Hawkesbury–Nepean Floodplain.

Select locations: Wisemans Ferry (1908), Ebenezer, Windsor, Richmond, Emu Plains.

Habitat

Habitat: Creeks, roadsides and disturbed habitats.

Altitude: 0–100 m

Annual rainfall: 700–1000 mm

Typical local abundance: Frequent.

Vegetation: Weeds in disturbed areas.

Substrate: Sandy riverbanks and rises, clay loams, fertile, watertable mostly low.

Exposure:

Conservation

Conservation: Minor weed.

Vernonia cinerea* var. *cinera

ASTERACEAE

Life history

Growth form: Herb to 0.6 m high with tubular purple or white flowers and thick taproot.

Vegetative spread: No.

Longevity: 1–5 years.

Primary juvenile period:

Flowers: White or purple, October–May, peak April.

Fruit/seed: Achene 1–2 mm long, with pappus 4–5 mm long. Mature October–May.

Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed (Westoby et al. 1990). Seedling establishment possibly related to disturbance.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC NT CT NWP; Qld, N.T., Africa, Asia.

Distribution Sydney area: Widespread especially Cumberland Plain.

Select locations: Hornsby, Silverwater, Ingleburn, Doonside, Douglas Park, Bulli, Bomaderry, Culoul Range, Grose Vale, Kowmung River.

Habitat

Habitat: Along roadsides and in grassland.

Altitude: 0–500 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: Grassy open-forest, e.g. with *Eucalyptus crebra*, *E. fibrosa*, *E. eugenioides*, *Syncarpia glomulifera*.

Substrate: Various — sandy riverbank, clay soil from basalt, shale. Soil very fertile–fertile–infertile. Watertable permanently low, moisture supply intermittent, fresh.

Exposure: Light shade.

Conservation

Conservation: Conserved in Western Sydney (Benson & McDougall 1991).

Vittadinia cervicularis* var. *cervicularis

ASTERACEAE

Life history**Growth form:** Herb.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** White–purple, October.**Fruit/seed:** Achene 8.5–10 mm long, pappus of bristles 6–9 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CT NWS NWP SWP SFWP; Vic., S.A., W.A.**Distribution Sydney area:** Hill End.**Select locations:** Hill End Bridle Track (1965) only record for area.**Habitat****Habitat:** Woodland and cleared land.**Altitude:** 600 m**Annual rainfall:** 900 mm**Typical local abundance:** Frequent.**Vegetation:** Eucalypt woodland.**Substrate:** Rocky hillside.**Exposure:****Conservation****Conservation:** Rare in Sydney area. Occurs mainly west of area, Hill End eastern limit; conservation status unknown.***Vittadinia cervicularis* var. *subcervicularis***

ASTERACEAE

Life history**Growth form:** Herb.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** White–purple, September–October.**Fruit/seed:** Achene 8.5–10 mm long, with pappus of bristles 6–9 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CWS NWP SWP SFWP; W.A.**Distribution Sydney area:** Silverdale.**Select locations:** Silverdale (1964) only Sydney record.**Habitat****Habitat:** Pasture, grassland and woodland.**Altitude:** 200 m**Annual rainfall:** 900 mm**Typical local abundance:****Vegetation:** Pasture and grassland.**Substrate:****Exposure:****Conservation****Conservation:** Rare in the Sydney area, Silverdale only record.

Vittadinia cuneata var. **cuneata** forma **cuneata** (Vittadinia form b) **ASTERACEAE**

Fuzzweed

Life history

Growth form: Woody herb 10–40 cm high.
Vegetative spread:
Longevity: Annual or perennial.
Primary juvenile period:
Flowers: Pale blue–mauve, October–March.
Fruit/seed: Achene 4–7 mm long, with pappus of bristles 4–8 mm long.
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT ST NWS CWS SWS NWP SWP NFWP SFWP; Vic., Tas., S.A.
Distribution Sydney area: Western Sydney.
Select locations: Grose Vale, St Marys, Emu Plains, Cobbitty.

Habitat

Habitat:
Altitude: 0–200 m **Annual rainfall:** 700–1000 mm
Typical local abundance:
Vegetation: Eucalypt forest and woodland.
Substrate: Clay soil from Wianamatta Shale.
Exposure:

Conservation

Conservation: Rare in Western Sydney, conservation status unknown.

Vittadinia cuneata var. **cuneata** forma **minor** (Vittadinia form a) **ASTERACEAE**

Fuzzweed

Life history

Growth form: Woody herb 10–40 cm high.
Vegetative spread:
Longevity: Annual or perennial.
Primary juvenile period:
Flowers: Pale blue–mauve, most of year, September–May.
Fruit/seed: Achene 4–7 mm long, with pappus of bristles 4–8 mm long.
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC NT CT ST NWS SWS; Vic.
Distribution Sydney area: Widespread.
Select locations: Morisset, Barranjoey, Pennant Hills, Bringelly, Doonside, Silverdale, Burragorang Valley, Jenolan Crossing, Bowral.

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** above 800 mm
Typical local abundance: Frequent.
Vegetation: Woodland, e.g. with *Eucalyptus fibrosa*, *E. melliodora*, *E. tereticornis* with grassy groundcover.
Substrate: Clay soil from shale and sandstone.
Exposure:

Conservation

Conservation: Status unknown.

Vittadinia dissecta* var. *dissecta

ASTERACEAE

Life history**Growth form:** Herb 10–35 cm high.**Vegetative spread:****Longevity:** Annual or short-lived perennial.**Primary juvenile period:****Flowers:** White–blue, most of the year.**Fruit/seed:** Achene 5 mm long, with pappus of bristles 5 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC; Qld, Vic.**Distribution Sydney area:** Sporadic, mainly coastal.**Select locations:** Mt Kembla (1889), Kiama (1850), Penrith (1888).**Habitat****Habitat:****Altitude:** 0–300 m**Annual rainfall:** above 800 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Apparently rare, last collected 1889.***Vittadinia gracilis* (*Vittadinia* sp. E)**

ASTERACEAE

Life history**Growth form:** Small shrub 10–40 cm high, with woody base.**Vegetative spread:****Longevity:** 1–5 years.**Primary juvenile period:** Less than 1 year.**Flowers:** Purple, September–December.**Fruit/seed:** Achene 5–6 mm long, with pappus of bristles 5–7 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CC SC CT ST CWS SWS NWP SWP SFWP; Vic., Tas., S.A.**Distribution Sydney area:** Mainly Bathurst–Orange.**Select locations:** Panania, Flemington Saleyards, Bathurst, Orange.**Habitat****Habitat:** Roadsides, pastures.**Altitude:** 0–1000 m**Annual rainfall:** 800–1200 mm**Typical local abundance:** Frequent.**Vegetation:****Substrate:** Clay soils from shale, fertile.**Exposure:****Conservation****Conservation:** Few collections, status unknown.

Vittadinia hispidula* var. *hispidula

ASTERACEAE

Life history

Growth form: Erect herb.
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: White–purple, August.
Fruit/seed: Achene 3 mm long, with pappus of bristles 5 mm long.
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed. ✓
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC CT NT; Qld.
Distribution Sydney area: North of Sydney
Select locations: Colo Heights (1958), Ku-ring-gai Chase (1916).

Habitat

Habitat:
Altitude: 0–300 m **Annual rainfall:** above 900 mm
Typical local abundance: Rare.
Vegetation: Eucalypt forest.
Substrate: Gravelly clay.
Exposure:

Conservation

Conservation: Apparently rare, Ku-ring-gai Chase is southern limit, conservation status unknown.

***Vittadinia hispidula* var. *setosa* (*Vittadinia hispidula*)**

ASTERACEAE

Life history

Growth form: Erect herb.
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: White–purple, July.
Fruit/seed: Achene 3 mm long, with pappus of bristles 5 mm long.
Dispersal, establishment & growth: Diaspore: fruit, wind-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC; Qld.
Distribution Sydney area:
Select locations: Como (1896) only Sydney record.

Habitat

Habitat: Roadsides and beach areas.
Altitude: 0–100 m **Annual rainfall:** above 1100 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Apparently rare, conservation status unknown.

Vittadinia muelleri (Vittadinia sp. G)

ASTERACEAE

Life history

Growth form: Herb with woody rootstock and tufted stems.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Bluish-purple, September–May.**Fruit/seed:** Achene 5 mm long, with pappus of bristles 7 mm long, mature September–May.**Dispersal, establishment & growth:** Diaspore: fruit, no strong after-ripening requirement, wind-dispersed. Germination promoted by light. Germination promoted by high temperature and cold-stratification, optimum germination regime 25°/15°C. (Willis & Groves 1991).**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** CC SC NT CT ST NWS CWS SWS; Qld, Vic., Tas.**Distribution Sydney area:** Western Sydney and Southern Highlands.**Select locations:** Windsor, St Marys, Bringelly, The Oaks, Narellan, Berrima (1889), Woodhouselee.

Habitat

Habitat: Grassland.**Altitude:** 0–700 m**Annual rainfall:** 600–900 mm**Typical local abundance:** Rare.**Vegetation:** Grassland. Ground stratum.**Substrate:** Wianamatta Shale. Fertile soil. Watertable permanently low, moisture supply intermittent, fresh.**Exposure:** Full sun.

Conservation

Conservation: Probably now rare. Vulnerable in Western Sydney (Benson & McDougall 1991), conservation status unknown.**Vittadinia pustulata** (Vittadinia sp. H)

ASTERACEAE

Life history

Growth form: Herb or small shrub 10–30 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** September–March.**Fruit/seed:** Achene 3–4 mm long, with pappus of bristles 5–7 mm long.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** CC CWS NWP; Qld, N.T., S.A., W.A.**Distribution Sydney area:** Western Sydney.**Select locations:** Blacktown, Castlereagh, Penrith, Regentville, Silverdale, Ingleburn, Camden.

Habitat

Habitat: Disturbed sites, roadsides.**Altitude:** 0–300 m**Annual rainfall:** 700–900 mm**Typical local abundance:****Vegetation:** Grassland, Cumberland Plain Woodland, e.g. with *Eucalyptus moluccana*, *E. tereticornis*.**Substrate:** Clay soils from Wianamatta Shale, fertile.**Exposure:**

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991), conservation status elsewhere unknown.

Vittadinia sulcata (Vittadinia sp. F)

ASTERACEAE

Life history

Growth form: Herb 10–30 cm high.**Vegetative spread:** No.**Longevity:** Annual.**Primary juvenile period:** Less than 1 year.**Flowers:** Purple, August–October.**Fruit/seed:** Achene 5–8 mm long, with pappus of bristles 6–8 mm long, matures March–April, August.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC NWS SWS NWP SWP NFWP; all mainland States.**Distribution Sydney area:** South-western Sydney.**Select locations:** Como, Minto, Regentville, Razorback, Douglas Park, Goodmans Ford.

Habitat

Habitat: Open grassy areas.**Altitude:** 0–200 m**Annual rainfall:** 700–1000 mm**Typical local abundance:** Occasional.**Vegetation:** Grassland or grassy woodland, e.g. with *Eucalyptus albens*, *E. melliodora*, *Angophora floribunda*.**Substrate:** Dry sites, probably clay soils.**Exposure:**

Conservation

Conservation: Conservation status unknown.**Vittadinia tenuissima**

ASTERACEAE

Western New Holland Daisy

Life history

Growth form: Slender herb to more than 40 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Spring.**Fruit/seed:** Achene 3–4 mm long, with pappus of bristles 5 mm long, mature March.**Dispersal, establishment & growth:** Diaspore: fruit, wind-dispersed.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC NT CWS; Qld, Vic.**Distribution Sydney area:****Select locations:** Wollemi NP (1982), Grose Vale (1910), Grose Vale (1910), Kiama (1850).

Habitat

Habitat: Disturbed sites.**Altitude:** 0–400 m**Annual rainfall:** above 900 mm**Typical local abundance:****Vegetation:****Substrate:** Fertile soils, basalt intrusions (Wollemi).**Exposure:**

Conservation

Conservation: Apparently rare, conservation status unknown.

***Xanthium cavanillesii* ***

ASTERACEAE

South American Burr

Life history**Growth form:** Monoecious herb to 1 m high with scabrous stems.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Summer-autumn.**Fruit/seed:** Burr 15–30 mm long with spines, achenes retained inside, mature December–May.**Dispersal, establishment & growth:** Diaspore: burr, animal-dispersed, also spread in floodwaters and along watercourses.**Fire response:****Interaction with other organisms:** Hybridises with *Xanthium occidentale*.**Distribution****Status/origin:** Naturalised exotic, native of America.**Botanical subregions:** CC CWS;**Distribution Sydney area:** Banks of Hawkesbury River.**Select locations:** Wisemans Ferry, Ebenezer, Windsor (1915), Richmond, Castlereagh.**Habitat****Habitat:** Riverbanks.**Altitude:** 0–100 m**Annual rainfall:** 800–900 mm**Typical local abundance:****Vegetation:****Substrate:** Sandy loam.**Exposure:****Conservation****Conservation:** Naturalised along Hawkesbury-Nepean but has not shown the same ability to spread as other *Xanthium* species (Milvain 1983).***Xanthium occidentale* *** (*Xanthium chinese*, *X. pungens*)

ASTERACEAE

Noogoora Burr, Cockle Burr

Life history**Growth form:** Herb to 2 m high with stout taproot, stems hairy and purplish.**Vegetative spread:** No.**Longevity:** 6–9 months.**Primary juvenile period:** Less than 1 year.**Flowers:** Inconspicuous, flowering determined by day length, late February–April (Milvain 1983).**Fruit/seed:** Hard, woody burr 16–18 mm long, with hooked spines. Each burr with 2 different sized seeds, upper and lower, retained inside. No pappus on achenes. Mature April–June.**Dispersal, establishment & growth:** Diaspore: burr; animal-dispersed, also water-dispersed, float and spread in floodwater and along watercourses. Non-dormant seed will germinate in 2 days, dormant seed may germinate after 3 weeks (Langkamp 1987). Upper seed exhibits innate dormancy, overcome by high temperature and exposure to light; induced dormancy in the lower seed following soil-storage during summer, overcome by storage in soil over winter or by high temperature and exposure to light. Seeds germinate in late spring following favourable weather or along waterways following a rise and fall of water levels when temperatures are high (Milvain 1993). Summer-growing. Plants die off in autumn but burrs remain on the dead plant until next season.**Fire response:** Killed by high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).**Interaction with other organisms:** Toxic to stock if eaten. 3 insects and a fungus have been released since 1932 for control but have been unsuccessful (Milvain 1983). Attacked by gall-forming moth *Epiblema strenuana* recently introduced from Mexico (Common 1990).

Distribution

Status/origin: Naturalised exotic, native to N America. Introduced into Australia with cotton seed from the Mississippi delta and first discovered in Australia in late 1860s at Noogoora Station near Ipswich Qld (Milvain 1983).

Botanical subregions: NC CC NT NWS CWS SWS NWP SWP NFWP SFWP; all mainland States.

Distribution Sydney area: Hawkesbury–Nepean floodplain, Georges River, Cooks River.

Select locations: Pennant Hills, Westmead, Cooks River (1911), Ermington, Casula, Colo River, Richmond, Castlereagh, Cabramatta, Cobbitty, Royal NP.

Habitat

Habitat: Riverbanks, creeks.

Altitude: 0–100 m **Annual rainfall:** 700–1200 mm

Typical local abundance: Frequent–occasional.

Vegetation: Ground stratum, with riverbank weed species.

Substrate: Sandy loam, fertile. Watertable mostly high, moisture supply intermittent.

Exposure: Sheltered, light shade–full sun.

Conservation

Conservation: Widespread along rivers and creeks and flats after late spring or summer flooding. Declared noxious weed in all States.

Xanthium spinosum* **ASTERACEAE**

Bathurst Burr

Life history

Growth form: Monoecious herb to 1 m high with taproot, stems pubescent, armed with 3-pronged spines at base of leaves.

Vegetative spread: No.

Longevity: 1–6 months.

Primary juvenile period: 1–4 months.

Flowers: January–March.

Fruit/seed: Burr 10–12 mm long with hooked spines, each with 2 brown seeds, a smaller soft seed that germinates in the first season and a larger, harder seed that does not germinate until the 2nd or 3rd year or later (Milvain 1991). Burr contains an upper and a lower seed (Langkamp 1987). Adheres to hair of stock or wool of sheep causing considerable annoyance (Herbarium note).

Dispersal, establishment & growth: Diaspore: burr, dispersed by animals, humans and water (Ciba-Geigy 1968–). Non-dormant seed will germinate in 2 days, dormant seed may germinate after 3 weeks; this species exhibits enforced dormancy, the burr may restrict gas exchange (Langkamp 1987). Germinates in spring–summer following rain, flowers January–March. Later-establishing plants flower and seed within a few weeks.

Fire response:

Interaction with other organisms: Attacked by gall-forming moth *Epiblema strenuana* recently introduced from Mexico (Common 1990). Plant believed to be toxic at early stages until development of roots (Milvain 1991). A mycoherbicide *Colletotrichum orbiculare* is being developed for biological control (Tanner 1993).

Distribution

Status/origin: Naturalised exotic, native to S America, known from Bathurst in 1840s, considered naturalised by 1850.

Botanical subregions: NC CC SC CT ST NWS CWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Lane Cove River, Centennial Park, Cooks River, St Marys, Kangaroo Valley, Goodmans Ford, Wolgan River, Clarence (1900).

Habitat

Habitat: Agricultural ground and disturbed pastures.

Altitude: 0–1000 m **Annual rainfall:** above 800 mm

Typical local abundance: Frequent–occasional.

Vegetation:

Substrate: Sandy loam, fertile soils, watertable mostly high. Recorded on saline

sites in western NSW (Semple 1993).

Exposure:

Conservation

Conservation: Widespread and seasonally abundant weed often forming prolific stands after summer rain or flooding. Declared noxious in all Australian states.

Avicennia marina* subsp. *australasica

AVICENNIACEAE

Grey Mangrove

Life history

Growth form: Small tree or shrub to 12 m high with aerating roots or pneumatophores, projecting above the surrounding mud. Secretes salt through glands on leaves (West 1985). Multistemmed forms sometimes found (P. Clarke pers. comm.).

Vegetative spread: Occasionally low-lying branches take root and become independent from the adult plant (P. Clarke pers. comm.).

Longevity: Up to 100 years (Clarke 1992).

Primary juvenile period: 5 years (Clarke 1992).

Flowers: February–March, peak March. Flowering of individual trees varies greatly between years and many trees fail to reproduce each year although the populations remain fecund from year to year. Pollen vector most commonly bees, also ants, wasps, bugs (Lygaeidae, Miridae), flies (Cecidomyiidae), bee flies, Cantherid beetles, moths (Pyralidae) (Clarke & Myerscough 1991).

Fruit/seed: Compressed capsule about 3 cm diameter with one seed. 'Seed' mass 5–20 g (P. Clarke pers. comm.), mature October–November, peak November. Seed with two large cotyledons folded longitudinally, germinating before fruit falls. Seed supply not stored on plant.

Dispersal, establishment & growth: Diaspore: germinating seed dropped in December (Hamilton 1919). Dispersed by tidal water, floating in saltwater, sinking in fresh (P. Clarke pers. comm.). Seedlings establish in mud and grow vigorously to about 30 cm high; newly silted areas readily colonised. Optimum growth and establishment occurs just above mid-tide level; seedlings in mature forests grow to about 0.6 m and remain at this height for up to 5 years and die through lack of light and space (State Pollution Control Commission n.d.). Pneumatophore damage may result in plant death (West 1985). Plants may be killed by oil spills (Allaway 1982, Grant et al. 1993).

Fire response: Variable response to high-intensity fire (1/1994) at Lane Cove, some killed others resprouted (P. Kubiak pers. comm.). Canopy killed, resprouts from base (at Breakfast Creek 1994). Can resprout from basal stems, but is also killed if small; killed at Jervis Bay (1989); fires possibly keep it out of the upper saltmarsh (P. Clarke pers. comm.).

Interaction with other organisms: One km² of *Avicennia* forest contributes 600 tonnes of leaf litter each year to the detrital food chain (West 1985). Crabs aid the decomposition of leaf litter, 50% eaten (Van der Valk & Attiwill 1984). Flower bud predation by moth larvae (subtribe Phycitina) may be high but had little effect on ovule survival (Clarke 1992).

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC; LHI, all mainland States, NG, Pac Is, SE Asia.

Distribution Sydney area: Saltwater swamps and estuaries.

Select locations: Gosford, Broken Bay, Bantry Bay (L.McD.), Middle Harbour Creek (L.McD.), Parramatta River, Cooks River, Botany Bay, Georges River, Lake Illawarra, Minnamurra River.

Habitat

Habitat: Mudflats with tidal inundation; occasionally on rock platforms in sheltered bays (P. Clarke pers. comm.).

Altitude: Sea level only.

Annual rainfall: Above 1200 mm.

Typical local abundance: Dominant and often monospecific (P. Clarke pers. comm.).

Vegetation: Closed-forest/closed-scrub as sole dominant, occasionally with zones of *Aegiceras corniculata*.

Substrate: In mud, fertile silt and sand deposits below upper tidal limit. Watertable high fluctuating in response to tide, saline.

Exposure: Indifferent to exposure, light. Seedling growth greater in canopy gaps, recruitment to sapling size restricted by light and sediment resources (Clarke & Allaway 1992).

Conservation

Conservation: Extensive reclamation of mangrove areas has destroyed much mangrove habitat, but there has also been some recent expansion of some mangrove areas in response to increased siltation from disturbed catchments. Species adequately conserved, though protection of mangrove forest is important for maintenance of estuarine habitat. Survey estimated 107 km² of mangroves in NSW 'a resource needing careful management in the future' (West 1985).

Impatiens walleriana *

BALSAMINACEAE

Balsam, Busy Lizzie

Life history

Growth form: Glabrous herb to 1 m high with more or less succulent stems.

Vegetative spread: Can regrow from stem fragments.

Longevity: Short-lived, less than 5 years.

Primary juvenile period: Less than 1 year.

Flowers: Pink-red or white, November–May.

Fruit/seed: Capsule 15 mm long, explosively dehiscent.

Dispersal, establishment & growth: Diaspore: seed, explosively dehiscent, dispersed by gravity or water (Anon 1991). Can regrow from dumped stems.

Fire response: Probably killed, flowered within 18 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to southern Africa, cultivated as ornamental, occasionally naturalised.

Botanical subregions: CC.

Distribution Sydney area: Sydney suburban bushland.

Select locations: Wahroonga (M. Clarke pers. comm.), Beecroft, Lane Cove, Clifton Gardens, Minto (1969).

Habitat

Habitat: Gardens, bushland, rubbish dumps. Especially along stormwater drains and creeks (R. Buchanan per. comm.).

Altitude: 0–200 m **Annual rainfall:** above 900 mm

Typical local abundance: Frequent–occasional.

Vegetation: Moist forest, e.g. with *Eucalyptus pilularis*, *E. piperita*, or with *Syncarpia glomulifera* (M. Clarke pers. comm.).

Substrate: Enriched sandstone soils, alluvial soils, fertile. Watertable mostly high, intermittent, fresh.

Exposure: Sheltered sites; deep shade–mid shade.

Conservation

Conservation: Occasionally found in sheltered bushland, probably mainly spread in garden refuse. Spread by water in creeks and stormwater drains (R. Buchanan & M. Clarke pers. comm.).

Anredera cordifolia *

BASELLACEAE

Madeira Vine, Lamb's Tail, Jalap

Life history

Growth form: Climber with stems to 30 m long producing tubers on roots and at nodes on aerial stems.

Vegetative spread: Aerial and underground tubers (R. Buchanan pers. comm.).

Longevity:

Primary juvenile period:

Flowers: White, fragrant, March.

Fruit/seed: Fruit not set in Australia.

Dispersal, establishment & growth: Diaspore: large underground tubers or clusters of aerial tubers (up to 10 cm diam. in Sydney area, larger on North Coast (M. Clarke pers. comm.); these may remain viable in the soil for many years before sprouting (McLoughlin & Rawling 1990). Dispersal: gravity or water; tubers washed into creeks in stormwater, rubbish dumping.

Fire response: Rarely burnt (R. Buchanan pers. comm.). Resprouted after high-intensity fire (1/1994) at Narrabeen, one seedling observed (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to S America.

Botanical subregions: NC CC SC NWS CWS NWP.

Distribution Sydney area: Coast.

Select locations: Cheltenham, Eastwood, Balmoral Beach, Glebe Point (1894), Flemington, Royal National Park, Kurrajong, Kangaroo Valley.

Habitat

Habitat: Roadsides, creekbanks, wasteland — sheltered gullies on margins of rainforests and near old settlements.

Altitude: 0–400 m **Annual rainfall:** above 800 mm

Typical local abundance: Frequent.

Vegetation: Margins of rainforest and moist forests. Canopy stratum.

Substrate: Clay soils from Wianamatta Shale, Alluvium. Enriched sandstone, e.g. at Balmoral Beach (M. Clarke pers. comm.). Soil fertile. Watertable mostly low, moisture supply intermittent, fresh.

Exposure: Dense shade–full sun, stem only elongates rapidly in light shade–full sun (R. Buchanan pers. comm.).

Conservation

Conservation: An invasive weed of bushland margins.

Bauera capitata

BAUERACEAE

Life history

Growth form: Small diffuse shrub to 30 cm with woody rootstock.

Vegetative spread: Probably not.

Longevity:

Primary juvenile period:

Flowers: Pink, September–October.

Fruit/seed: Capsule, mature October.

Dispersal, establishment & growth: Diaspore: seed.

Fire response: Probably resprouts at ground level or below.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC; Qld.

Distribution Sydney area: Coast south to La Perouse.

Select locations: Tuggerah (1900), La Perouse (1893–1913).

Habitat

Habitat: Wet heath.

Altitude: 0–30 m **Annual rainfall:** above 1200 mm

Typical local abundance: Now extremely rare or possibly extinct in Sydney region.

Vegetation: Wet heath. Ground stratum.

Substrate: Deep sand, possibly sometimes associated with weathered volcanic dykes?

Exposure:

Conservation

Conservation: Only old records. Probably extinct in the Sydney area, La Perouse is southern limit for the species.

Bauera microphylla**BAUERACEAE****Life history**

Growth form: Small trailing shrub to 30 cm high.

Vegetative spread: May form adventitious roots but not clear whether capable of spread.

Longevity: ? 25–60 years (D. Keith).

Primary juvenile period: 3–4 years (D. Keith).

Flowers: White–pink, August–January, April–May. Flowers visited by birds and insects, but mostly by small beetles, all of which get well dusted by pollen (Sulman 1914).

Fruit/seed: Capsule which splits lengthwise to release numerous seeds, mature September–November.

Dispersal, establishment & growth: Diaspore: seed, with ant-adapted food body (Westoby et al. 1990), ant-dispersed.

Fire response: Resprouts, seedling recruitment mainly after fire (D. Keith).

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC.

Distribution Sydney area: Coast and Blue Mountains (rare), Woronora Plateau.

Select locations: Mangrove Mountain, Gosford, Wahroonga, Centennial Park, Botany, Audley, Heathcote, Appin, Mt Ousley, Lawson (1899), Butlers Swamp.

Habitat

Habitat: Open sandy heath, swamps.

Altitude: 0–900 m **Annual rainfall:** above 1200 mm

Typical local abundance: Frequent–occasional.

Vegetation: Wet heath, e.g. with *Leptospermum polygalifolium*, *Banksia ericifolia*.

Sedgeland/wet heath, also ecotone area between sedgeland/wet heath and grassland/sclerophyll forest (P. Kodala pers. comm.). Ground stratum.

Substrate: Deep sandy soils on sandstone or dune sand. Peaty soil on wetland, sandy organic soils (P. Kodala pers. comm.). Soil very infertile. Watertable mostly high, moisture supply continuous, fresh.

Exposure: Light shade–full sun.

Conservation

Conservation: Conservation status unknown.

Bauera rubioides**BAUERACEAE****Life history**

Growth form: Scrambling shrub to 2 m high.

Vegetative spread: No.

Longevity:

Primary juvenile period: 4 years.

Flowers: Pink or white, April–November, peak September.

Fruit/seed: Capsule which splits lengthwise to release numerous seeds. Mature December.

Dispersal, establishment & growth: Diaspore: seed. Dispersal: ant-adapted food body (Westoby et al. 1990).

Fire response: Resprouts at ground level or below. Seedlings can flower within 4 years (after fire, Brisbane Water NP). Killed after high-intensity fire (1/1994) at Lane Cove and Narrabeen, soil-stored seed probably destroyed by high-intensity fire, seedlings in ditches and cliffines where fire intensity lower (P. Kubiak pers. comm.).

Interaction with other organisms: Flowers visited by birds and insects, but mostly by small beetles, all of which get well dusted by pollen (Sulman 1914).

Distribution

Status/origin: Native.

Botanical subregions: CC CT ST; Qld, Vic., Tas., S.A.

Distribution Sydney area: Coast and upper Blue Mountains.

Select locations: West Head Rd, Asquith, Lindfield, Asquith, Marsfield, Oatley, Kentlyn, Appin, Bargo, Mt Wilson, Mt Victoria, Orange.

Habitat

Habitat: Wet and often shaded situations.

Altitude: 0–1000 m

Annual rainfall: above 1000 mm

Typical local abundance: Frequent.

Vegetation: Creekside scrub in moist eucalypt open-forest, e.g. with *Eucalyptus piperita*, *Angophora costata*. Ground-mid-stratum.

Substrate: Damp sandy soil from sandstone. Soil infertile. Watertable mostly high, moisture supply continuous, fresh.

Exposure: Sheltered, mid-light shade.

Conservation

Conservation: Probably adequately conserved. Conserved in Western Sydney (Benson & McDougall 1991).

Berberis aristata* **BERBERIDACEAE****Life history**

Growth form: Evergreen shrub to 3 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Yellow, 10 mm diam.

Fruit/seed: Berry 9–11 mm long, bright red to pruinose blue, mature January–March.

Dispersal, establishment & growth: Diaspore: berry, possibly bird-dispersed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Asia. Cultivated as an ornamental, sometimes naturalised.

Botanical subregions: CC CT NT.

Distribution Sydney area: Southern Highlands and Illawarra.

Select locations: Yerranderie (1953), Macquarie Pass, Bowral (1992), Exeter (1937).

Habitat

Habitat: Rural areas.

Altitude: 0–800 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent.

Vegetation: Disturbed eucalypt woodland, e.g. with *Acacia melanoxylon*.

Substrate: Probably clay soils, fertile, old silver mine area.

Exposure:

Conservation

Conservation: Probably minor weed.

Berberis darwinii* **BERBERIDACEAE****Life history**

Growth form: Evergreen shrub to 3 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Yellowish-red, May.

Fruit/seed: Blue berry 6–7 mm long, mature May.

Dispersal, establishment & growth: Bird-dispersed (Carr et al. 1992).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America. Cultivated in cooler districts, rarely naturalised.

Botanical subregions: CT.

Distribution Sydney area: Blue Mountains.

Select locations: Mt Wilson (1949).

Habitat

Habitat:

Altitude: 900–1000 m

Annual rainfall: above 1200 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Rarely naturalised.

Mahonia leschenaultii *

BERBERIDACEAE

Life history

Growth form: Evergreen shrub.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Bright yellow, October (Yass, only record).

Fruit/seed: Blue berry 7–8 mm long.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to India, E Asia. Often cultivated as an ornamental occasionally naturalised in gullies in Blue Mountains, or Robertson Plateau (P. Kodela pers. comm.).

Botanical subregions: CT ST.

Distribution Sydney area: Blue Mountains, Southern Highlands.

Select locations: Mt Wilson (1948), Robertson–Wildes Meadow (P. Kodela pers. comm.).

Habitat

Habitat: Gullies.

Altitude: 750–1000 m

Annual rainfall: above 1200 mm

Typical local abundance: Rare.

Vegetation: Disturbed moist *Eucalyptus fastigata* forest with rainforest understorey, growing light in gap (P. Kodela pers. comm.).

Substrate: Fertile soil on basalt (P. Kodela pers. comm.).

Exposure:

Conservation

Conservation: Occasionally naturalised.

Macfadyena unguis-cati *

BIGNONIACEAE

Cat's Claw Creeper

Life history

Growth form: Woody climber to 30 m, with recurved tendrils; 2 leaflets and terminal leaflet modified into a 3-branched tendril.

Vegetative spread: Underground tuber (R. Buchanan pers. comm.).

Longevity:

Primary juvenile period:

Flowers: Yellow, spring, November.

Fruit/seed: Capsule 14–45 cm long, with winged seeds, 20–40 mm long.

Dispersal, establishment & growth: Diaspore: winged seeds, wind-dispersed (Anon 1991).

Fire response: Resprouts from tubers (R. Buchanan pers. comm.).

Interaction with other organisms:

	Distribution
Status/origin: Naturalised exotic, native to Brazil and Argentina; cultivated as an ornamental.	
Botanical subregions: NC CC NT; Qld.	
Distribution Sydney area: Ourimbah.	
Select locations: Ourimbah (1959); Berowra Waters, Epping (R. Buchanan & M. Clarke pers. comm.), North Richmond, Camden.	
	Habitat
Habitat: Roadside, water's edge.	
Altitude: 0–100 m Annual rainfall: above 1200 mm	
Typical local abundance:	
Vegetation: Disturbed rainforest, tall open-forest (M. Clarke pers. comm.).	
Substrate: Alluvial and clay soils, well-drained, very fertile.	
Exposure: Deep shade–full sun, stems only elongated rapidly in light shade–full sun (R. Buchanan pers. comm.).	
	Conservation
Conservation: An aggressive weed in disturbed rainforest and moist eucalypt forest remnants north of Sydney. Localised problem in parts of Sydney, e.g. Berowra Waters (R. Buchanan pers. comm.). Camden Park (M. Clarke pers. comm.).	

Pandorea pandorana

BIGNONIACEAE

Wonga Wonga Vine

Life history

Growth form: Woody, often tall, glabrous climber, with twining branches.
Vegetative spread: No.
Longevity: Medium-long (? 50–100 years).
Primary juvenile period:
Flowers: Cream with mauve-purple markings, June–November, peak August–September. Bird-pollinated.
Fruit/seed: Capsule 4–6 cm long splitting to release numerous, beautifully-packed winged seeds, 10–15 mm diam. (Sulman 1914). Mature November–January.
Dispersal, establishment & growth: Diaspore: winged seed, wind-dispersed (Westoby et al. 1990). Soil-stored seedbank (Fox 1988).
Fire response: Killed by fire (Fox 1988). Resprouted after high-intensity fire (1/1994) at Lane Cove, a few plants flowering within 26–29 weeks (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP SFWP; LHI, Qld, Vic., N.T., S.A., W.A., NG, Malesia.
Distribution Sydney area: Widespread
Select locations: Wyong, Avoca Beach, Cheltenham, Oatley, Grose Vale, Genbrook, Kentlyn, Razorback, Macquarie Pass, Barren Grounds, Robertson.

Habitat

Habitat: Moist gullies, rocky sites.
Altitude: 0–800 m **Annual rainfall:** above 1000 mm
Typical local abundance: Frequent.
Vegetation: Coastal rainforest, e.g. with *Ceratopetalum apetalum*, *Doryphora sassafras*, *Cupaniopsis anacardioides*, *Acmena smithii*. Tableland rainforest, e.g. mixed cool temperate/warm rainforest with *Ceratopetalum*, *Doryphora sassafras*, *Acmena smithii*, *Acacia melanoxylon* (P. Kodala pers. comm.). Also a component of dry rainforest vine scrub. Sclerophyll forest and woodland, e.g. with *Syncarpia glomulifera*; often persisting in cleared areas.
Substrate: Medium-high nutrient soils, clay influence, watertable permanently low, moisture supply intermittent.
Exposure: Sheltered sites.

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991). Conservation elsewhere probably adequate.

***Pyrostegia venusta* ***

BIGNONIACEAE

Flame Vine

Life history

Growth form: Woody climber.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Reddish orange, spring–summer.

Fruit/seed: Capsule 20–30 cm long, but apparently does not set seed in Australia (Harden 1992).

Dispersal, establishment & growth: Diaspore: probably vegetative.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Brazil and Paraguay. Cultivated, occasionally naturalised in coastal districts.

Botanical subregions: NC CC.

Distribution Sydney area: Lane Cove.

Select locations: Lane Cove (1991) only Sydney record.

Habitat

Habitat: Creekbank.

Altitude: 0–100 m

Annual rainfall: 1200 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Occasionally naturalised in coastal districts.

***Tecoma capensis* ***

BIGNONIACEAE

Cape Honeysuckle

Life history

Growth form: Rambling shrub to 3 m high.

Vegetative spread: Spreads by stoloniferous branches (layering) along ground surface.

Longevity:

Primary juvenile period:

Flowers: Orange to scarlet with much nectar, spring–summer.

Fruit/seed: Capsule 3 cm long, with winged seed 15 mm long.

Dispersal, establishment & growth: Diaspore: seed not set here (L. Johnson pers. comm.).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S Africa. Cultivated as an ornamental, sometimes as a hedge plant.

Botanical subregions: NC CC.

Distribution Sydney area: Coast.

Select locations: Muogamarra NR, Eastwood (1978), Harbord (1981).

Habitat

Habitat: Disturbed sites.

Altitude: 0–200 m

Annual rainfall: above 1200 mm

Typical local abundance: Occasional.

Vegetation: Moist eucalypt forest.

Substrate: Clay soils, fertile.

Exposure:

Conservation

Conservation: Probably just persistent remnant of old gardens or dispersed in garden refuse; fruit not set here (L. Johnson pers. comm.).

***Tecoma stans* ***

BIGNONIACEAE

Tecoma

Life history**Growth form:** Shrub to 4 m high.**Vegetative spread:****Longevity:****Primary juvenile period:****Flowers:** Yellow with reddish lines, spring–summer.**Fruit/seed:** Capsule 10–22 mm long, with winged seeds 20 mm long.**Dispersal, establishment & growth:** Diaspore: winged seeds.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Mexico, Peru & Ecuador. Commonly cultivated as ornamental but rarely naturalised (Harden 1992).**Botanical subregions:** NC CC ?SC; Qld.**Distribution Sydney area:** North Avoca.**Select locations:** Bulbararing Lagoon North Avoca (1990), Lapstone station (1993, P. Kodela pers. comm.).**Habitat****Habitat:****Altitude:** 0–50 m**Annual rainfall:** above 1200 mm**Typical local abundance:****Vegetation:** Disturbed lagoon that previously had *Melaleuca quinquenervia*–*Casuarina glauca* swamp forest with *Baumea juncea* understorey.**Substrate:** Sandy, infertile soil on edge of lagoon. Watertable permanently high, moisture supply continuous, brackish–fresh.**Exposure:****Conservation****Conservation:** Reported to be beginning to invade other parts of the Central Coast on a range of soil types (R. Payne pers. comm.).***Amsinckia calycina* *** (*Amsinckia hispida*)

BORAGINACEAE

Life history**Growth form:** Herb 15–50 cm high.**Vegetative spread:** No.**Longevity:** 6–8 months.**Primary juvenile period:** 4–6 months.**Flowers:** August–January.**Fruit/seed:** Fruit of 4 mericarps, 2–2.5 mm long, November–January. Up to 1600 seeds/plant (Dellow 1989). Seeds remain viable for at least 2 years.**Dispersal, establishment & growth:** Diaspore: mericarp, dispersed by livestock and clothing. Low temperatures favour germination. Seeds germinate after autumn rains and there may be up to 4 germinations in a season. Plants grow in winter and die off in late spring–early summer (Dellow 1989).**Fire response:****Interaction with other organisms:** Plants or seeds can poison stock if they have access for long periods (Dellow 1989).**Distribution****Status/origin:** Naturalised exotic, native to S America.**Botanical subregions:** CC CT ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., N.T., S.A., W.A.**Distribution Sydney area:** Western Sydney, but mainly Bathurst–Orange area.**Select locations:** Flemington, Campbelltown, Bathurst (1925), Mandurama, Freemantle, Orange, Canobolas.**Habitat****Habitat:** Soil dumps, waste and cultivated land.**Altitude:** 0–1400 m**Annual rainfall:** 600–1200 mm

Typical local abundance: Occasional.
Vegetation: Winter cereal crops. Ground stratum.
Substrate: Basalt soil, fertile.
Exposure:

Conservation

Conservation: Weed of winter cereal crops (Dellow 1989). Weed of waste and cultivated land.

***Amsinckia intermedia* ***

BORAGINACEAE

Common Fiddleneck

Life history

Growth form: Herb 30–100 cm high, with rosette leaves.
Vegetative spread: No.
Longevity: 6–8 months (Dellow 1989).
Primary juvenile period: 4–6 months.
Flowers: Orange-yellow, September–December.
Fruit/seed: Fruit of 4 mericarps, each 3 mm long. Up to 1600 seeds/plant; seeds remain viable for at least 2 years (Dellow 1989).
Dispersal, establishment & growth: Diaspore: mericarp, animal-dispersed on fur and clothing, farm machinery and contaminated grain; probably also bird-dispersed. Farming activities spread the weed over large areas (Parsons 1973). Seeds germinate after autumn rains and there may be up to 4 germinations in a season; low temperatures favour germination but this is not uniform, winter provides ideal conditions; plants grow in winter and die off in late spring–early summer (Dellow 1989).
Fire response:
Interaction with other organisms: Plants or seeds can poison stock if they have access for long periods; seeds can taint and discolour flour made from contaminated seed (Dellow 1989).

Distribution

Status/origin: Naturalised exotic, native to N America. Probably introduced in fodder imported during drought (Parsons 1973). Now spread by contaminated seed wheat.
Botanical subregions: NC CC CT ST NWS CWS SWS NWP SWP; Qld, Vic.
Distribution Sydney area:
Select locations: Concord (1966), Blayney (1903 first record for State), Trunkey, Bathurst, Orange.

Habitat

Habitat: Weed of cultivated land, rubbish tip (Concord).
Altitude: 0–1200 m **Annual rainfall:** 600–1200 mm
Typical local abundance: Frequent.
Vegetation: Winter cereal crops. Ground stratum.
Substrate: Agricultural soils, not confined to any particular soil type (Parsons 1973).
Exposure:

Conservation

Conservation: Weed of winter cereal crops (Dellow 1989).

***Anchusa arvensis* * (Lycopsis arvensis)**

BORAGINACEAE

Wild Bugloss

Life history

Growth form: Erect herb to 60 cm high.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Blue or rarely whitish, October–December.
Fruit/seed: Mericarp 2 mm long, mature January–May.
Dispersal, establishment & growth: Diaspore: fruit. Seedling recruitment possibly related to disturbance.
Fire response:
Interaction with other organisms:

Status/origin: Naturalised exotic, native to Europe. Botanical subregions: NT CT ST NWS CWS SWP; Vic., Tas., S.A. Distribution Sydney area: Bathurst–Orange. Select locations: Jenolan Caves (1899), Oberon, Blayney, Orange, Mt Canobolas summit.	Distribution
Habitat: Disturbed sites, e.g. roadsides. Altitude: 800–1400 m Annual rainfall: 800–1200 mm Typical local abundance: Frequent. Vegetation: Ruderal weeds, e.g. <i>Echium</i> , <i>Verbena</i> , <i>Oenothera</i> . Ground stratum. Substrate: Agricultural soils, basalt, fertile. Watertable mostly low, moisture supply intermittent, fresh. Exposure:	Habitat
Conservation: Weed of disturbed sites.	Conservation

Austrocynoglossum latifolium (Cynoglossum latifolium)

BORAGINACEAE

Growth form: Decumbent herb with trailing stems to 1 m long. Stems cling to neighbouring vegetation by means of prickly-like setules (Mill 1989). Vegetative spread: Longevity: Primary juvenile period: Flowers: White, November–May. Fruit/seed: Fruit of 4 spiny mericarps, 3.5 mm long, densely prickly, November–June. Dispersal, establishment & growth: Diaspore: mericarp. Fire response: Interaction with other organisms:	Life history
Status/origin: Native. Botanical subregions: NC CC SC NT CT ST; Qld, Vic. Distribution Sydney area: Illawarra and Western Blue Mountains. Select locations: Bulli Pass, Macquarie Rivulet, Cambewarra, Robertson, Bilpin, Mt Wilson, Kanangra Deep, Jenolan Caves.	Distribution
Habitat: Typically in rainforest, on damp soil of creek banks, near waterfalls; frequently near or in caves (Mill 1989). Altitude: 0–1000 m Annual rainfall: above 900 mm Typical local abundance: Frequent–occasional. Vegetation: Moist eucalypt forest and margins of rainforest. Also within rainforest (P. Kodala pers. comm.). Substrate: Basalt and shale soil, very fertile–fertile. Watertable mostly high, moisture supply intermittent, fresh. Seems to prefer well-drained limestone or basaltic soils (Mill 1989). Exposure: Sheltered; deep shade.	Habitat
Conservation: Rare close to Sydney area, but more common elsewhere, e.g. in Kowmung area (L. Johnson pers. comm.).	Conservation

Borago officinalis* **BORAGINACEAE**

Borage

Life history**Growth form:** Herb 30–80 cm high.**Vegetative spread:** No.**Longevity:** Annual.**Primary juvenile period:** Less than 1 year.**Flowers:** White, spring.**Fruit/seed:** Mericarp, 6 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to S Europe. Cultivated, rarely naturalised. Re-establishes from seed in gardens, not seen doing so elsewhere (L. Johnson pers. comm.).**Botanical subregions:** CC ST; Vic., S.A., W.A.**Distribution Sydney area:****Select locations:** Beecroft, North Sydney (1915), Campbelltown.**Habitat****Habitat:** Old gardens, pasture.**Altitude:** 0–1000 m**Annual rainfall:** above 700 mm**Typical local abundance:** Rare.**Vegetation:** Old gardens, ground stratum.**Substrate:** Probably clay soils, fertile. Watertable permanently low, moisture supply intermittent, fresh.**Exposure:****Conservation****Conservation:** Rarely naturalised.***Buglossoides arvensis* * (Lithospermum arvense)****BORAGINACEAE**

Sheepweed

Life history**Growth form:** Erect herb to 45 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** White-cream, August–October.**Fruit/seed:** Fruit of 2 mericarps, 4 mm long.**Dispersal, establishment & growth:** Diaspore: mericarp.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe.**Botanical subregions:** CC NT CT ST NWS CWS SWS NWP SWP NFWP; Qld, Vic., Tas., N.T., S.A., W.A.**Distribution Sydney area:** Sydney, Orange.**Select locations:** Royal Botanic Gardens (1902), Centennial Park, Richmond, Flemington, Casula, Orange (1911), Rylstone.**Habitat****Habitat:** Weed of disturbed places, e.g. railway lines.**Altitude:** 0–1000 m**Annual rainfall:** above 600 mm**Typical local abundance:** Rare.**Vegetation:** Ground stratum.**Substrate:****Exposure:****Conservation****Conservation:** Weed of disturbed places.

Cynoglossum australe

BORAGINACEAE

Life history

Growth form: Erect herb 30–75 cm high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Blue–whitish, September–March.

Fruit/seed: Fruit of 4 spiny mericarps, densely prickly, mature November–July, peak November.

Dispersal, establishment & growth: Diaspore: mericarp. Seedling recruitment possibly related to soil disturbance.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Coast and Blue Mountains.

Select locations: Howes Valley, Mt Tomah, Sans Souci, Razorback, Douglas Park, Mt Towinhingy, Glanmire, Orange, Abercrombie Caves, Bullio.

Habitat

Habitat: Sites with disturbed soil, e.g. roadside.

Altitude: 0–1000 m **Annual rainfall:** above 600 mm

Typical local abundance: Occasional.

Vegetation: Margins of rainforest, wet eucalypt forest in grassy sites, e.g. with *Eucalyptus deanei*. Ground stratum.

Substrate: Mainly on basalt soil but also on sandy soil and skeletal slate soils, fertile–infertile. Watertable mostly low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (Benson & McDougall 1991). Conservation status elsewhere unknown.

Cynoglossum suaveolens

BORAGINACEAE

Life history

Growth form: Erect herb to 50 cm high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: White or sometimes blue, October–May.

Fruit/seed: Fruit of 4 spiny mericarps, densely prickly, mature November–December.

Dispersal, establishment & growth: Diaspore: mericarp.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., S.A.

Distribution Sydney area: Coast and western Blue Mountains.

Select locations: Colo, Middle Harbour, Georges River, Menangle Park, Mt Victoria, Jenolan Caves, Cullen Bullen, Orange, Bowral.

Habitat

Habitat: Damp places.

Altitude: 0–1000 m **Annual rainfall:** above 800 mm

Typical local abundance: Occasional.

Vegetation: Eucalypt open-forest and grassland; ground stratum.

Substrate: Shaley sandstone or clay soils, infertile, damp.

Exposure:

Conservation

Conservation: Not common, probably not well conserved, mostly old records. Vulnerable in Western Sydney (Benson & McDougall 1991).

Echium plantagineum * (*Echium lycopsis*)

BORAGINACEAE

Paterson's Curse, Salvation Jane

Life history

Growth form: Herb to 150 cm high, usually multi-stemmed, with short, stout taproot and numerous laterals, overwinters as rosettes (Parsons & Cuthbertson 1992).

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period: Usually less than 1 year (Parson 1973).

Flowers: Purple, pinkish or white, September–April, peak November.

Fruit/seed: Fruit of 4 mericarps, mature December–January, April. Plants produce large amount of seed, most of which falls to ground within a few feet of plant (Parsons 1973). Can produce more than 30,000 seeds per m² (Parsons & Cuthbertson 1992).

Dispersal, establishment & growth: Diaspore: mericarp. Dispersed by animals, water, and as a contaminant of grain (Parsons & Cuthbertson 1992). Seed coat is roughened and seeds can adhere to wool and fur; seeds retain viability after passing through the alimentary tract of animals; seed viability for at least 5 years; cultivation stimulates germination of dormant seed (Parsons 1973). Seed shows considerable innate and temperature enforced dormancy that appears to permit sporadic germination over several seasons (Piggin 1976). Recruitment probably related to moisture availability and temperature. Can germinate at any time, especially autumn; can be found at any time of year in all stages of growth (Parsons 1973). Favoured by Mediterranean-type climate especially in years with early seasonal breaks (Piggin 1976).

Fire response:

Interaction with other organisms: Foodplant of tiger moth caterpillars *Spilosoma glatignyi* and *Utetheisa pulchelloides* (Coupar & Coupar 1992). Used by beekeepers as a source of nectar and pollen (Harden 1991). Seeds eaten by birds, Richard's Pipit *Anthus novaeseelandiae* (Barker & Vestjens 1989, 1990). Roots eaten by Sulphur-crested Cockatoo *Cacatua galerita* (Lepschi 1993). Stiff, sharp hairs on stems and leaves are abrasive to skin of humans (Southcott & Haegi 1992). Pollen known to cause allergic rhinitis in humans (Bass 1987). Cattle and horses usually avoid the plant; particularly poisonous to pigs and horses, causes liver damage, it is also mutagenic and possibly carcinogenic (Parsons & Cuthbertson 1992). Biological control using *Echium* Leaf-miner *Dialectica scalarisella* since 1988, other control agents being released are root feeding *Echium* Weevils *Ceutorhynchus geographicus* and *C. larvatus* (Tanner 1993).

Distribution

Status/origin: Naturalised exotic, native to Europe. Recorded at Camden in 1843, introduced by John Macarthur as an ornamental (Parsons & Cuthbertson 1992).

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Terrigal, Pennant Hills, Richmond, Doonside, Glenfield, Mt Annan, Bomaderry, Carcoar (1915), Rockley, Orange, Robertson (P. Kodala pers. comm.).

Habitat

Habitat: Roadsides and pastoral land.

Altitude: 0–1000 m **Annual rainfall:** above 600 mm

Typical local abundance: Frequent.

Vegetation: Woodland, grassland.

Substrate: Shale, basalt — fertile soil. Recorded on saline sites in western NSW (Semple 1993).

Exposure: Full sun.

Conservation

Conservation: Regarded as a weed in cultivated and pastoral land.

***Echium vulgare* ***

BORAGINACEAE

Viper's Bugloss

Life history**Growth form:** Herb, to 90 cm high.**Vegetative spread:** No.**Longevity:** 2 years, but sometimes perennial (Parsons 1873).**Primary juvenile period:****Flowers:** Blue, November–April.**Fruit/seed:** Fruit of 4 mericarps, mature April.**Dispersal, establishment & growth:** Diaspore: mericarp. Large amounts of seed produced, most falls to ground within a few feet of plant. Seeds spread by movement of stock and fodder, can pass through alimentary tract of animals and remain viable, can adhere to wool and fur. 80% germination for 1–2 years but can lie dormant for at least 5 years. Seedling recruitment from soil-stored seed possibly related to disturbance (Parsons 1973).**Fire response:****Interaction with other organisms:** Causes liver damage in stock. Important throughout history in herbal medicine, used as a diuretic and treatment for fevers, headaches etc. (Parsons & Cuthbertson 1992).**Distribution****Status/origin:** Naturalised exotic, native to Europe. Introduced to Australia in 1820 (Parsons & Cuthbertson 1992).**Botanical subregions:** NC NT CT ST NWS SWS NWP; Vic., Tas., S.A.**Distribution Sydney area:** Bathurst–Lithgow area, Southern Highlands.**Select locations:** Glen Alice, Portland, Lithgow, Cox River (1909), Raglan, Tarana, Oberon, Rockley, Robertson (P. Kodala pers. comm.).**Habitat****Habitat:** Disturbed sites, roadsides, pastoral land, wasteland.**Altitude:** above 800 m **Annual rainfall:** 800–1200 mm**Typical local abundance:** Frequent.**Vegetation:** Eucalypt woodland, e.g. *Eucalyptus bridgesiana*, *E. polyanthemos*, *E. albens*, *E. melliodora* with ruderal weeds, e.g. *Echium plantagineum*, *Cirsium vulgare*. Ground stratum.**Substrate:** Loamy soils from granite. Wide variety of soils (Parsons & Cuthbertson 1992).**Exposure:****Conservation****Conservation:** Weed of pastoral land.***Ehretia acuminata* var. *acuminata***

BORAGINACEAE

Koda

Life history**Growth form:** Tree to 30 m high with creamy-brown bark, often more or less deciduous, with new growth in spring.**Vegetative spread:** No.**Longevity:****Primary juvenile period:****Flowers:** White, strongly scented, October–January, peak December.**Fruit/seed:** Orange-yellow drupe 5–7 mm diam., breaking into pyrenes at maturity, February–March.**Dispersal, establishment & growth:** Diaspore: fruit, probably bird-dispersed. Germination of sown fresh seed very rapid, 28% germination after 20 days (Floyd 1989).**Fire response:****Interaction with other organisms:** Fruit eaten by Brown Cuckoo-Dove, Figbird, Green Catbird, Lewin's Honeyeater, Rose-crowned Fruit-dove, Wompoo Fruit-dove (Floyd 1989). Timber used for furniture, resembles English Elm (Floyd 1983).**Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT CT CWS; Qld.**Distribution Sydney area:** Coast and coastal ranges.

Select locations: Ourimbah Creek, Grose Vale, Cobbitty, Razorback, Kowmung, Barrengarry, Saddleback, Minnamurra Falls, Kangaroo Valley.

Habitat

Habitat: Rainforest along creeks.

Altitude: 0–300 m

Annual rainfall: above 800 mm

Typical local abundance: Occasional–rare.

Vegetation: Warmer rainforest, especially near the margins or in disturbed areas, e.g. with *Doryphora sassafras*, *Toona ciliata*, *Acmena smithii*, *Cryptocarya glaucescens*. Canopy stratum.

Substrate: Deep sandy alluvium along creeks, sometimes on basalt. Fertile soil. Watertable mostly high, non-saline.

Exposure: Sheltered situations.

Conservation

Conservation: Conservation status unknown. Fairly common in marginal rainforest area (L. Johnson pers. comm.).

Halganina brachyrhyncha

BORAGINACEAE

Life history

Growth form: Spreading–semi-prostrate subshrub 0.3–0.6 m high.

Vegetative spread:

Longevity:

Primary juvenile period:

Flowers: Deep blue, September–February.

Fruit/seed: Leathery drupe 4–5 mm long, with 1–2 seeds.

Dispersal, establishment & growth: Diaspore: drupe.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: CC SC CWS; Qld.

Distribution Sydney area: Burragorang Valley.

Select locations: Burragorang Valley (The Sheepwalk 1967) only record for area.

Habitat

Habitat: Rocky sites particularly ridges or hillsides.

Altitude: 200 m

Annual rainfall: 800 mm

Typical local abundance:

Vegetation: Tall shrubland to woodland and open-forest. Ground stratum.

Substrate: Sandstone or conglomerate. Infertile soil.

Exposure:

Conservation

Conservation: Rare, only known from a few localities (Wilson 1990), conservation status unknown.

Heliotropium amplexicaule *

BORAGINACEAE

Blue Heliotrope

Life history

Growth form: Perennial herb to 15 cm high with deep taproot.

Vegetative spread: No.

Longevity:

Primary juvenile period:

Flowers: Purple or lilac, November–March.

Fruit/seed: Fruit of 2 mericarps, succulent at first, becoming wrinkled and falling at maturity, November–March.

Dispersal, establishment & growth: Diaspore: mericarp, shed at maturity. A summer-growing perennial that dies back in winter and regrows from the taproot in spring.

Fire response:

Interaction with other organisms: Contains toxic alkaloids, suspected of causing jaundice in sheep (Mitchell 1988).

Distribution

Status/origin: Naturalised exotic, native to S America. Probably introduced as a garden plant.

Botanical subregions: NC CC SC NT CT NWS CWS NWP NFWP; Qld, Vic., S.A.

Distribution Sydney area: Widespread.

Select locations: Barrenjoey, Ermington, Summer Hill (1913), Agnes Banks, Penrith, Ingleburn, Mt Annan, Bathurst.

Habitat

Habitat: Roadsides, creekbanks, degraded and overstocked pastures.

Altitude: 0–1000 m **Annual rainfall:** above 600 mm

Typical local abundance: Occasional.

Vegetation: Ephemeral weeds or woodland, e.g. with *Eucalyptus tereticornis*. Ground stratum.

Substrate: Generally restricted to well drained alluviums and medium to sandy soils (Mitchell 1988), fertile–infertile.

Exposure:

Conservation

Conservation: Major agricultural weed in upper reaches of Macquarie River, but not an invader of bushland. Declared noxious weed in some shires of NSW.

Heliotropium europaeum

BORAGINACEAE

Common Heliotrope, Potato Weed

Life history

Growth form: Herb, erect, to 30 cm high.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: White, February–March.

Fruit/seed: Fruit of mericarps 4, shed at maturity, March–April.

Dispersal, establishment & growth: Diaspore: mericarp. Spring and summer-growing annual.

Fire response:

Interaction with other organisms: May cause jaundice in sheep, cumulative effects resulting in death (Mitchell 1988). Foodplant of tiger moth caterpillar *Utetheisa pulchelloides* (Coupar & Coupar 1992). Rust Fungus *Uromyces heliotropii* has been released for biological control (Keech & Tanner 1993).

Distribution

Status/origin: Cosmopolitan. Has been regarded as introduced and naturalised in Australia, but is now considered to be cosmopolitan (Harden 1992).

Botanical subregions: NC CC CT ST NWS CWS SWS NWP SWP NFWP SFWP; Vic., S.A., W.A., SW Asia & Europe.

Distribution Sydney area:

Select locations: Royal Botanic Gardens, Flemington (1969), Glenfield (1969).

Habitat

Habitat: Earthworks and garden beds.

Altitude: 0–200 m **Annual rainfall:** above 700 mm

Typical local abundance: Rare.

Vegetation: Disturbed sites.

Substrate: Clay soil. Recorded on saline sites in western NSW (Semple 1993).

Exposure:

Conservation

Conservation: Rare, conservation status unknown.

Myosotis australis

BORAGINACEAE

Australian Forget-me-not

Life history**Growth form:** Herb 20–40 cm high.**Vegetative spread:****Longevity:** Annual or perennial.**Primary juvenile period:****Flowers:** White or yellowish or rarely bluish, November–December.**Fruit/seed:** Fruit of 4 mericarps.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC SC NT CT ST NWS CWS SWS; Vic., Tas., S.A., W.A.**Distribution Sydney area:** Blue Mountains and westward. Southern Highlands (P. Kodela pers. comm.).**Select locations:** Mt Tomah, Jenolan Caves, Mt Shivering, Mt Canobolas, Robertson (P. Kodela pers. comm.).**Habitat****Habitat:** Rocky hillsides.**Altitude:** 800–1400 m**Annual rainfall:** above 800 mm**Typical local abundance:** Occasional.**Vegetation:** Open-forest, e.g. *Eucalyptus fastigata*, *E. viminalis*, *Pellaea falcata*. Ground stratum.**Substrate:** Basalt soil, fertile. Watertable mostly low, non-saline.**Exposure:****Conservation****Conservation:** Rare, conservation status unknown.***Myosotis caespitosa* ***

BORAGINACEAE

Life history**Growth form:** Herb 10–35 cm high.**Vegetative spread:****Longevity:** Annual.**Primary juvenile period:** 1 year.**Flowers:** Pale blue changing to pink, spring–summer.**Fruit/seed:** Fruit of 4 mericarps.**Dispersal, establishment & growth:** Diaspore: mericarp.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic (P. Kodela pers. comm.), native to Europe.**Botanical subregions:** NC NT CT ST CWS.**Distribution Sydney area:** Southern Highlands.**Select locations:** Burrawang–Robertson (1992).**Habitat****Habitat:** Disturbed roadside.**Altitude:** 700 m**Annual rainfall:** 1600 mm**Typical local abundance:** Occasional.**Vegetation:** With grasses and other herbs, near pastures.**Substrate:****Exposure:****Conservation****Conservation:** Localised minor weed of roadsides.

***Myosotis discolor* ***

BORAGINACEAE

Forget-me-not

Life history**Growth form:** Herb 10–20 cm high.**Vegetative spread:** No.**Longevity:** 1–2 years.**Primary juvenile period:****Flowers:** Yellowish–blue, October–November.**Fruit/seed:** Fruit of 4 mericarps.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe. *Myosotis caespitosa* and *M. sylvatica* also naturalised in Sydney area at Robertson (P. Kodela pers. comm.).**Botanical subregions:** CT ST NWS SWS; Vic., Tas.**Distribution Sydney area:****Select locations:** Jenolan Caves, Abercrombie Caves, Mt Jellore, Canobolas SF.**Habitat****Habitat:** Rocky crevices.**Altitude:** 700–1000 m**Annual rainfall:** 800–1000 mm**Typical local abundance:** Frequent.**Vegetation:** Open-woodland, e.g. with *Eucalyptus dives* and *Cassinia* understorey. Ground stratum.**Substrate:** Rocky crevices on limestone, occasionally volcanic rocks. Soil fertile.**Exposure:** Sheltered.**Conservation****Conservation:*****Myosotis exarrhena* (*Myosotis suaveolens*)**

BORAGINACEAE

Life history**Growth form:** Herb 30–50 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Pale blue or white, October.**Fruit/seed:** Fruit of 4 mericarps.**Dispersal, establishment & growth:** Diaspore; mericarp.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NT CT ST; Vic., Tas.**Distribution Sydney area:** Jenolan Caves.**Select locations:** Jenolan Caves (1899) only Sydney record.**Habitat****Habitat:****Altitude:** 800 m**Annual rainfall:** 900 mm**Typical local abundance:****Vegetation:** Ground stratum.**Substrate:** Probably on limestone soil.**Exposure:****Conservation****Conservation:** Rare, conservation status unknown.

***Myosotis sylvatica* ***

BORAGINACEAE

Wood Forget-me-not

Life history**Growth form:** Herb to 40 cm high, with hairs on stems and leaves.**Vegetative spread:****Longevity:** 2 years, biennial or perennial.**Primary juvenile period:****Flowers:** Bright blue with yellow throat, spring–summer.**Fruit/seed:** Fruit of 4 mericarps.**Dispersal, establishment & growth:** Diaspore: mericarp.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to Europe, introduced as garden plant, sometimes naturalised.**Botanical subregions:** CT ST; Vic., Tas., S.A.**Distribution Sydney area:** Southern Highlands.**Select locations:** Kangaloon (1993).**Habitat****Habitat:** Roadside.**Altitude:** 800 m**Annual rainfall:** 1600 mm**Typical local abundance:** Frequent.**Vegetation:** With roadside weeds, e.g. *Holcus lanatus*, *Dactylis glomerata*, *Bromus catharticus* etc.**Substrate:****Exposure:** Mid shade.**Conservation****Conservation:** Rare in Sydney area, probably only localised garden escape (P.

Kodala pers. comm.).

***Barbarea verna* ***

BRASSICACEAE

Wintercress

Life history**Growth form:** Erect herb to 75 cm high.**Vegetative spread:****Longevity:** 2 years.**Primary juvenile period:****Flowers:** Yellow.**Fruit/seed:** Capsule (silique) 3–7 cm long, with row of seeds, mature February.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to Europe. Garden escape, rarely naturalised.**Botanical subregions:** CC; Vic., Tas., S.A.**Distribution Sydney area:****Select locations:** Wahroonga (1917). (Only one specimen available.)**Habitat****Habitat:****Altitude:** 200 m**Annual rainfall:** 1300 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Garden escape, rarely naturalised. Not recorded in the last 75 years.

***Brassica fruticulosa* ***

BRASSICACEAE

Twiggy Turnip

Life history**Growth form:** Herb, erect, to 50 cm high.**Vegetative spread:** No.**Longevity:** Less than 5 years.**Primary juvenile period:****Flowers:** Pale yellow-white, April–November.**Fruit/seed:** Capsule (siliqua) 2–4 cm long, with small seeds, mature April–November.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:** Probably killed, flowering within 12 weeks, seeds released within 28 weeks of high-intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic. Native to S Europe and N Africa. Supposedly originally introduced from Italy as a vegetable (note with Herbarium specimen).**Botanical subregions:** NC CC CT; Vic.**Distribution Sydney area:** Sydney suburbs, Katoomba.**Select locations:** Beecroft, West Ryde (1949), Northbridge, Dobroyd Point, La Perouse, Mortdale, Liverpool, Echo Point (1966).**Habitat****Habitat:** Disturbed sites, roadsides, creek banks, embankments, railway edges.**Altitude:** 0–1000 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Herbaceous weeds. Ground stratum.**Substrate:** Various — sandy soil, reclaimed sites; also on highly disturbed Wianamatta Shale around Marsfield (L. Johnson pers. comm.).**Exposure:****Conservation****Conservation:** Appears mainly confined to suburban areas, often in soil-fill.***Brassica juncea* ***

BRASSICACEAE

Indian Mustard

Life history**Growth form:** Herb to 1 m high, with slender taproot (Häfliger 1988).**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Pale yellow, spring.**Fruit/seed:** Capsule (siliqua), 2–6 cm long, 2–4 mm wide, with 16–24 seeds, 1.3–1.6 mm long, dark reddish brown to yellowish (Häfliger 1988), mature October.**Dispersal, establishment & growth:** Diaspore: seed. Winter-growing annual.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe and Asia.**Botanical subregions:** CC NT ST CWS SWP; Qld, S.A., W.A.**Distribution Sydney area:** Hornsby.**Select locations:** Hornsby (1924), Casula (1967), Belrose (P. Kodela pers. comm.).**Habitat****Habitat:** Agricultural lands, railway line, roadsides.**Altitude:** 0–100 m**Annual rainfall:** 1200 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** Weed of agricultural lands and roadsides.

***Brassica rapa* subsp. *silvestris* ***

BRASSICACEAE

Turnip

Life history**Growth form:** Herb to 1 m high; tap root sleek, often tuberous (Lamp & Collet 1989).**Vegetative spread:** No.**Longevity:** 1–2 years.**Primary juvenile period:****Flowers:** Bright yellow, April–November.**Fruit/seed:** Capsule 4–7 cm long, with small seeds, mature April–November.**Dispersal, establishment & growth:** Diaspore: probably seed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe. Introduced as food plant.**Botanical subregions:** NC CC NT CT ST CWS SWS SWP NFWP; Qld, Vic., Tas., N.T., S.A., W.A.**Distribution Sydney area:** Coastal.**Select locations:** Wondabyne, Glenorie, Hornsby (1909), Mosman, La Perouse, Glenfield, Albion Park, Meadow Flat Creek.**Habitat****Habitat:** Disturbed sites and roadsides.**Altitude:** 0–1000 m**Annual rainfall:** above 800 mm**Typical local abundance:** Occasional.**Vegetation:** Roadside weed species. Ground stratum.**Substrate:** Alluvial and clay soils, fertile.**Exposure:****Conservation****Conservation:** Widely cultivated and established as minor weed of disturbed sites.***Brassica tournefortii* ***

BRASSICACEAE

Mediterranean Turnip

Life history**Growth form:** Herb with mostly basal leaves, to 60 cm high; long taproot (Häfliger 1988).**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Pale yellow–white, August–October.**Fruit/seed:** Capsule (silique), 3–7 cm long, 3 mm wide, splitting at maturity, August–October. Seeds reddish-brown, 2 mm diam, about 16 per capsule.**Dispersal, establishment & growth:** Diaspore: seed. Possibly wind-dispersed (Carr et al. 1992).**Fire response:****Interaction with other organisms:** Rarely grazed by stock (Cunningham et al. 1981).**Distribution****Status/origin:** Naturalised exotic, native to Mediterranean.**Botanical subregions:** NC CC ST SWS NWP SWP NFWP SFWP; all mainland States.**Distribution Sydney area:** Coast.**Select locations:** Tuggerah Beach, Richmond, Woollooware Bay, Wollongong (1948).**Habitat****Habitat:** Coastal dunes.**Altitude:** 0–100 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Scrub with *Leptospermum laevigatum*, *Acacia longifolia* var. *sophorae*.**Substrate:** Sandy coastal dune soils — unstable. Soil infertile. Watertable permanently low, moisture supply intermittent.**Exposure:****Conservation****Conservation:** Widespread aggressive weed. Also occurs on sand in inland regions, e.g. Western Plains (L. Johnson pers. comm.).

***Cakile edentula* ***

BRASSICACEAE

American Sea Rocket

Life history**Growth form:** Herb to 80 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** White, pink or lavender, all year.**Fruit/seed:** Capsule (silicula) 12–24 mm long, corky, breaking into two segments (usually 1 seed in each) and capable of floating in seawater for 10 weeks with encased seeds remaining viable (Rodman 1986). Mature March–June.**Dispersal, establishment & growth:** Diaspore: silicula segments, local and widespread dispersal by water, local wind dispersal of plant as tumbleweed. Germination 59%, 1 week from sowing after scarification (Rodman 1986). Seeds not viable after burial (Clarke 1989). Seedlings sun-tolerant (Clarke 1989).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to N America. Probably introduced to Australia in ship ballast.**Botanical subregions:** NC CC SC; LHI, Qld, Vic., Tas., W.A.**Distribution Sydney area:** Coastline.**Select locations:** Wyong, Palm Beach, Manly (1870), Bondi (1884), La Perouse, Lady Robinson Beach, Kurnell, Wollongong, Austinmer, Seven Mile Beach.**Habitat****Habitat:** Beach dunes and lake foreshores.**Altitude:** 0–50 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Occasional.**Vegetation:** Strand zones.**Substrate:** Sand dunes, infertile soil.**Exposure:****Conservation****Conservation:** First recording for NSW at Manly Beach in 1870 after being introduced in Victoria (Rodman 1986).***Cakile maritima* ***

BRASSICACEAE

Sea Rocket

Life history**Growth form:** Herb with ascending or decumbent branches to 80 cm long.**Vegetative spread:** No.**Longevity:** Annual.**Primary juvenile period:****Flowers:** White–purple, August–September.**Fruit/seed:** Capsule (silicula) 12–27 mm long, corky. Upper fruit segment capable of floating in seawater for 2 weeks and encased seeds remain viable even after 10 weeks' exposure to seawater (Rodman 1986).**Dispersal, establishment & growth:** Diaspore: silicula segments, local and widespread dispersed by water; local wind dispersal of plant as tumbleweed. Germination 95%, 1 week from sowing after scarification (Rodman 1986).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe and Africa. Probably introduced to Australia in ships' ballast (Rodman 1986).**Botanical subregions:** CC SC NFWP; Vic., Bass Strait Is, S.A., W.A.**Distribution Sydney area:** Coastline: Broken Bay–Botany Bay.**Select locations:** Ettalong Beach (1969), Palm Beach, Belrose (P. Kodella), Towra Point (1977).

	Habitat
Habitat: Beaches and foreshores. Rarely away from coast, e.g. Belrose (P. Kodela pers. comm.).	
Altitude: 0–2 m Annual rainfall: above 1200 mm	
Typical local abundance: Rare.	
Vegetation: Strand zone. Ground stratum.	
Substrate: Beach sand, infertile. Rarely sandy soil on sandstone (P. Kodela pers. comm.).	
Exposure: Exposed situations.	
	Conservation
Conservation: Ettalong Beach is current northern limit and first record for NSW. It was first collected near Perth at the turn of the century, giving an estimated migration rate of 95 km per year (Rodman 1986).	

***Camelina alyssum* ***

BRASSICACEAE

Stinking Flaxweed

Life history

Growth form: Slender herb with flowers in racemes.
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Pale yellow.
Fruit/seed: Capsule (silicula) 6–12 mm long, with small seeds, mucilaginous when wet.
Dispersal, establishment & growth: Diaspore: seed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.
Botanical subregions: NC CC; Tas., S.A.
Distribution Sydney area: Parramatta.
Select locations: Parramatta (von Mueller, 19th century), no recent records.

Habitat

Habitat: Pasture weed.
Altitude: 0–50 m **Annual rainfall:** 1000 mm
Typical local abundance:
Vegetation: Pasture. Ground stratum.
Substrate:
Exposure:

Conservation

Conservation: Pasture weed, rare.

***Capsella bursa-pastoris* ***

BRASSICACEAE

Shepherd's Purse

Life history

Growth form: Erect herb 8–40 cm high, basal leaves in a rosette; taproot, becoming woody (Häfliger 1988).
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: White, May–December, peak September.
Fruit/seed: Capsule (silicula) 6–9 mm long, with small seeds, mature July–November.
Dispersal, establishment & growth: Diaspore: seed, animal and possibly wind-dispersed (Carr et al. 1992). Seedling: dark green, cotyledons petiolate, elliptical to oblong, 2–4 mm long (Häfliger 1988).
Fire response: Probably killed, seedlings seen, 1 plant flowering and fruiting within 20 weeks of high-intensity fire 1/1994 at Narrabeen (P. Kubiak pers. comm.).
Interaction with other organisms: Seed eaten by Galah *Cacatua roseicapilla* (Lepschi 1993).

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Sydney suburban area, Bathurst–Orange, Southern Highlands (P. Kodela pers. comm.).

Select locations: Curl Curl, Wollstonecraft, Technical College (1893), Flemington, Glenfield, Narellan, Wollongong, Bathurst, Orange, Robertson (P. Kodela pers. comm.).

Habitat

Habitat: Roadsides and footpaths, pastures.

Altitude: 0–1000 m **Annual rainfall:** above 600 mm

Typical local abundance: Frequent.

Vegetation: Amongst other wasteland weeds. Ground stratum.

Substrate: Fertile soil. Watertable permanently low, moisture supply intermittent, fresh.

Recorded on saline sites in western NSW (Semple 1993).

Exposure:

Conservation

Conservation: Common weed of roadsides and footpaths, does not invade bushland.

Cardamine flexuosa* **BRASSICACEAE**

Wood Bittercress

Life history

Growth form: Herb to 50 cm high.

Vegetative spread: No.

Longevity: 1 year (rarely perennial in Australia).

Primary juvenile period: Less than 1 year.

Flowers: White, sepals green–violet, March–September.

Fruit/seed: Capsule (silique) 10–25 mm long, with small seeds ejected suddenly at maturity, March–September.

Dispersal, establishment & growth: Diaspore: seed, ejected mechanically.

Fire response: Probably killed, fruiting within 15 weeks of high-intensity fire 1/1994 at Lane Cove, seedlings observed (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: CC.

Distribution Sydney area: Sydney suburban areas.

Select locations: Royal Botanic Gardens (1964), Padstow, Glenfield.

Habitat

Habitat: Garden beds.

Altitude: 0–300 m **Annual rainfall:** above 700 mm

Typical local abundance:

Vegetation:

Substrate: Moist garden beds, fertile.

Exposure:

Conservation

Conservation: Weed in moist garden sites, not invasive of bushland. Has increased greatly in past 30 years in moist garden sites; first appeared in nurseries (L. Johnson pers. comm.).

Cardamine gunnii**BRASSICACEAE****Life history**

Growth form: Robust herb, variable leaves entire–pinnatisect.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: White, August–October.

Fruit/seed: Capsule (silicula) 15–30 mm long, with small seeds ejected suddenly at maturity.

Dispersal, establishment & growth: Diaspore: seed, ejected mechanically. Seedling recruitment possibly related to disturbance.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NT CT ST; Vic., Tas., S.A.

Distribution Sydney area: Northern Blue Mountains.

Select locations: Mt Coricudgy, Mt Durambang, Mt Tayar, Gosling Creek, McKeons Creek (Jenolan Caves).

Habitat

Habitat: Moist forest.

Altitude: 500–1000 m

Annual rainfall: above 900 mm

Typical local abundance: Frequent.

Vegetation: Moist eucalypt forest, e.g. *Eucalyptus blaxlandii*, *E. viminalis*. Ground stratum.

Substrate: Clay loam on basalt, limestone, very fertile. Watertable mostly high, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Conservation status unknown.

Cardamine hirsuta *

BRASSICACEAE

Common Bittercress, Hairy Woodcress

Life history

Growth form: Slender herb to 30 cm high; taproot slender, much branched, yellowish (Häfliger 1988).

Vegetative spread: No (M. Clarke pers. comm.).

Longevity: 1 year.

Primary juvenile period: 6 months (P. Kubiak pers. com.).

Flowers: White, sepals green to violet, August–November.

Fruit/seed: Capsule (siliqua) 15–20 mm long, with small seeds ejected suddenly at maturity, August–November.

Dispersal, establishment & growth: Diaspore: seed, ejected mechanically, animal and possibly wind-dispersed (Carr et al. 1992). Water-dispersed (M. Clarke pers. comm.).

Fire response: Probably killed, flowering and fruiting within 24 weeks of high-intensity fire 1/1994 at Lane Cove (P. Kubiak pers. comm.).

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: NC CC ST NWS SWS; Qld, Vic., Tas., S.A., W.A.

Distribution Sydney area: Suburban areas.

Select locations: Cheltenham, Willoughby, Cremorne, Woolwich (1984), Centennial Park, Croydon Park.

Habitat

Habitat: Lawns and gardens, or disturbed sites, nurseries.

Altitude: 0–100 m

Annual rainfall: above 1000 mm

Typical local abundance: Frequent.

Vegetation: Lawns and gardens. Ground stratum.

Substrate: Garden soils, sandy, clay/shales, fertile–infertile, damp, non-saline.

Exposure: Dense–light shade (M. Clarke pers. comm.).

Conservation

Conservation: Confined to gardens and lawns. Watercourses, and stormwater outlets, invades bushland creeks.

Cardamine lilacina

BRASSICACEAE

Life history

Growth form: Herb to 50 cm high.**Vegetative spread:** No.**Longevity:** 1–5 years.**Primary juvenile period:****Flowers:** Pink–purple, sepals purple with white margins, October–November.**Fruit/seed:** Capsule (silique) 10–40 mm long, with small seeds ejected suddenly at maturity.**Dispersal, establishment & growth:** Diaspore: seed, ejected mechanically.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NT CT ST; Vic., Tas.**Distribution Sydney area:** Western Blue Mountains, Southern Highlands.**Select locations:** Mt Coricudgy, Coxs River (1904), Oberon, Wombeyan, Wingecarribee Swamp (1966).

Habitat

Habitat: Swamp, grassland, forest understorey.**Altitude:** 650–800 m**Annual rainfall:** above 800 mm**Typical local abundance:****Vegetation:** *Epacris paludosa*–*Sphagnum* bog and adjacent grassland, and forest, e.g. with *Eucalyptus dalrympleana* in herbaceous understorey. Ground stratum.**Substrate:** Granite, basalt, clay-loam, fertile–infertile soil. Watertable mostly high, moisture supply intermittent, fresh.**Exposure:** Light shade–full sun.

Conservation

Conservation: Probably rare and poorly conserved.*Cardamine paucijuga*

BRASSICACEAE

Life history

Growth form: Weak herb to 40 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** White or rarely pink, August–December.**Fruit/seed:** Capsule (silique) 10–30 mm long, with small seeds ejected suddenly at maturity, October.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC NT CT ST NWS SWS; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:** Western Blue Mountains, Southern Highlands.**Select locations:** Cheltenham, Maldon, Yerranderie, Mt Cameron, Little Hartley, Hill Top, Robertson (P. Kodela pers. comm.), Marulan.

Habitat

Habitat: Moist areas near creek banks.**Altitude:** 0–1000 m**Annual rainfall:** above 800 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Moist eucalypt forest, e.g. *Eucalyptus viminalis*, or with *Persicaria* spp. Ground stratum.**Substrate:** River gravels, river flat alluvium, granite and basalt. Soil very fertile–fertile.

Watertable mostly high, moisture supply intermittent, fresh.

Exposure: Sheltered situations.

Conservation

Conservation: Probably becoming rare, conservation status unknown.

Cardamine species Y

BRASSICACEAE

Life history

Growth form: Herb to 40 cm high.

Vegetative spread:

Longevity: Perennial.

Primary juvenile period:

Flowers: White or pink, September–November.

Fruit/seed: Capsule (siliqua) 15–30 mm long, with small seeds ejected suddenly at maturity.

Dispersal, establishment & growth: Diaspore: seed, ejected mechanically.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NT CT ST; Vic., Tas., S.A.

Distribution Sydney area:

Select locations: Rylstone, Coxs River, Orange, Oberon, Wombeyan.

Habitat

Habitat: Wet places, creeks.

Altitude: 800–1000 m

Annual rainfall: above 800 mm

Typical local abundance: Frequent.

Vegetation: Undisturbed swamp vegetation and grassland. Ground stratum.

Substrate: Basalt, granite soils, fertile–infertile. Watertable mostly high, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Probably now rare, conservation status unknown.

Cardaria draba * (*Lepidium draba*)

BRASSICACEAE

Hoary Cress, White Weed

Life history

Growth form: Herb 15–cm high with extensive and deep root system; taproot and horizontal creeping roots with adventitious buds (Häfliger 1988). Erect, branching near the top, covered with fine downy hairs; main root 2 m deep (Parsons & Cuthbertson 1992).

Vegetative spread: Capable of vegetative spread; severed portions of the root system readily bud to form new plants (Scurfield 1962). Horizontal roots produce aerial shoots (Parsons & Cuthbertson 1992).

Longevity: Perennial.

Primary juvenile period: 2 years.

Flowers: Not usually produced until 2nd year, white, October–November.

Fruit/seed: Capsule (silicula) 3–4 mm long separating into 1 or 2-seeded units (nutlets), red-brown, 2.2 mm long. Single plant can produce 1000–5000 seeds (Parsons & Cuthbertson 1992).

Dispersal, establishment & growth: Diaspore: 1 or 2-seeded nutlets. High seed production and germination percentages. Non-dormant fraction 93% with germination decreasing with age, and zero after 3 years (Scurfield 1962 in Cunningham et al. 1981). Germinates in autumn to form rosettes in winter and spring. Flowering does not usually occur in the first year but older plants flower in spring after which the above-ground parts die off (Cunningham et al. 1981).

Fire response:**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic. Native to S Europe.**Botanical subregions:** CC NT CT ST NWS CWS SWS SWP; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:** Campbelltown, Bathurst–Orange area.**Select locations:** Campbelltown, Bathurst (1901), Orange.**Habitat****Habitat:** Roadsides, gardens and waste land.**Altitude:** 0–1000 m**Annual rainfall:** above 400 mm (Parsons &

Cuthbertson 1992)

Typical local abundance:**Vegetation:** Ground stratum.**Substrate:** Dry, uncultivated, heavy, fertile soils (Parsons & Cuthbertson 1992).**Exposure:** Would appear to be able to withstand prolonged cold (Scurfield 1962).

Unshaded (Parsons & Cuthbertson 1992).

Conservation**Conservation:** Widespread agricultural weed — not common.***Conringia orientalis* *****BRASSICACEAE**

Hare's Ear, Treacle Mustard

Life history**Growth form:** Erect herb 10–50 cm high, glabrous and glaucous; short whitish taproot (Häfliger 1988).**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** Yellow or greenish white, October.**Fruit/seed:** Capsule (silique) 4–14 mm long, with small seeds, mature November.**Dispersal, establishment & growth:** Diaspore: seed. Seedling: cotyledons petiolate, elliptical to ovate (Häfliger 1988).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to Europe.**Botanical subregions:** CC NWS CWS; Qld, Vic., S.A.**Distribution Sydney area:****Select locations:** Royal Botanic Gardens (1896) only record.**Habitat****Habitat:** Weed of agricultural land.**Altitude:** 0–50 m**Annual rainfall:** 1200 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:****Conservation****Conservation:** No records since 1896, not naturalised in the Sydney area.***Coronopus didymus* *****BRASSICACEAE**

Lesser Swinecress

Life history**Growth form:** Herb to 30 cm high; with taproot (Häfliger 1988).**Vegetative spread:** No.**Longevity:** 1–2 years.**Primary juvenile period:****Flowers:** White, less than 2 mm long, September.

Fruit/seed: Capsule (silicula) 1.5 mm long, separating at maturity into 2 1-seeded nutlets 1–2 mm diam., mature any time of year.
Dispersal, establishment & growth: Diaspore: nutlet. Seedling: cotyledons petiolate, club-shaped (Häfliger 1988). Late winter–early spring growing.
Fire response: Probably killed, fruiting within 15 weeks of high-intensity fire 1/1994 at Lane Cove, seedlings observed (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic. Native to America and Europe.
Botanical subregions: NC CC SC ST NWS SWS NWP SWP; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Sydney suburbs and Western Sydney.
Select locations: Woy Woy, Cheltenham, Homebush (1893), Neutral Bay, Royal Botanic Gardens, Shane Park, Richmond, Leuhmeah, Wollongong, Albion Park.

Habitat

Habitat: Lawns, gardens, roadsides, wasteland.
Altitude: 0–100 m **Annual rainfall:** above 700 mm
Typical local abundance: Frequent–occasional.
Vegetation: With other weeds of wasteland. Ground stratum.
Substrate: Mainly fertile clay soils from Wianamatta Shale but also sandy soils.
Exposure:

Conservation

Conservation: Weed of disturbed sites, unlikely to invade bushland.

Diplotaxis muralis *

BRASSICACEAE

Wall Rocket

Life history

Growth form: Herb to 60 cm high, with taproot.
Vegetative spread: No.
Longevity: 1–2 years.
Primary juvenile period:
Flowers: Lemon-yellow sometimes becoming violet after flowering, September.
Fruit/seed: Cylindrical capsule (siliqua) 3–4 cm long, opening when ripe, September. Numerous seeds, yellow brown 1.2 mm long.
Dispersal, establishment & growth: Diaspore: seed. Seedling: light green, cotyledons petiolate, roundish-elliptical, apex emarginate (Häfliger 1988).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic. Native to Europe.
Botanical subregions: CC CWS NFWP SFWP; Vic., Tas., S.A., W.A.
Distribution Sydney area: Campbelltown.
Select locations: Campbelltown (1954) only record.

Habitat

Habitat: Roadside gravel dump.
Altitude: 0–50 m **Annual rainfall:** 750 mm
Typical local abundance:
Vegetation: Ground stratum.
Substrate: Roadside gravel dump.
Exposure:

Conservation

Conservation: Widespread weed, only Sydney record Campbelltown (1954).

Drabastrum alpestre

BRASSICACEAE

Mountain Cress

Life history**Growth form:** Herb or subshrub 10–30 cm high, woody base and rhizome.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** White or lavender.**Fruit/seed:** Capsule (siliqua) 4–10 mm long, with small seeds.**Dispersal, establishment & growth:** Diaspore: seed, mucilaginous when wet.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** CT ST; Vic.**Distribution Sydney area:** Bathurst (Harden 1990).**Select locations:** No specimens in NSW Herbarium.**Habitat****Habitat:****Altitude:** Probably above 1000 m**Annual rainfall:** 600–1000 mm**Typical local abundance:****Vegetation:** Ground stratum.**Substrate:****Exposure:****Conservation****Conservation:** Rare, coded 3RC- (Briggs & Leigh 1988), Bathurst district is northern limit, conservation status unknown.***Erophila verna* subsp. *praecox* ***

BRASSICACEAE

Whitlow Grass

Life history**Growth form:** Herb 3–20 cm high; taproot slender, much branched, yellowish (Häfliger 1988).**Vegetative spread:** No.**Longevity:** Annual.**Primary juvenile period:****Flowers:** White or pink, September.**Fruit/seed:** Capsule (silicula) 3–6 mm long, with numerous minute seeds, mature September.**Dispersal, establishment & growth:** Diaspore: seed. Seedling: cotyledons petiolate, elliptical to roundish, c. 1 mm long (Häfliger 1988).**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to S Europe.**Botanical subregions:** CT ST CWS SWS; Vic., Tas., S.A.**Distribution Sydney area:** Bathurst–Orange.**Select locations:** Mt Tayar (1964), Kandos, Bathurst, Lucknow.**Habitat****Habitat:** Wet ground.**Altitude:** 700–100 m**Annual rainfall:** above 600 mm**Typical local abundance:** Frequent.**Vegetation:** Grassland. Ground stratum.**Substrate:** Basalt soil or stonework of old mine workings. Soil fertile. Watertable mostly high, moisture supply continuous, fresh.**Exposure:****Conservation****Conservation:**

***Erophila verna* subsp. *verna* ***

BRASSICACEAE

Whitlow Grass

Life history**Growth form:** Annual herb 3–20 cm high.**Vegetative spread:** No.**Longevity:** Annual.**Primary juvenile period:****Flowers:** White or pink, August–October.**Fruit/seed:** Capsule (silicula) 6–10 mm long, with numerous minute seeds, mature October.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to S Europe.**Botanical subregions:** CC SC NT CT ST CWS SWS; Vic., Tas., S.A.**Distribution Sydney area:** Bathurst–Oberon.**Select locations:** Wolgan Valley (1953), Bathurst, Hampton.**Habitat****Habitat:** Seepage areas.**Altitude:** 600–1000 m**Annual rainfall:** above 600 mm**Typical local abundance:** Occasional.**Vegetation:** Open-grassland. Ground stratum.**Substrate:** Grey clay, fertile. Watertable mostly high, moisture supply continuous, fresh.**Exposure:****Conservation****Conservation:*****Hirschfeldia incana* ***

BRASSICACEAE

Hairy Brassica, Buchan Weed

Life history**Growth form:** Herb to 1 m high.**Vegetative spread:** No.**Longevity:** Less than 5 years.**Primary juvenile period:****Flowers:** Yellow, often purple-veined, all year.**Fruit/seed:** Capsule 8–15 mm long, opening when ripe, February–May, 3–9 cells per cell.

Seed reddish brown 1 mm diam.

Dispersal, establishment & growth: Diaspore: seed, winter-spring growing.**Fire response:****Interaction with other organisms:** Seed eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).**Distribution****Status/origin:** Naturalised exotic, native to Mediterranean.**Botanical subregions:** CC SC NT CT ST NWS CWS SWS NWP SWP; S.A., Qld, Vic., Tas.**Distribution Sydney area:** Western Sydney, Bathurst area.**Select locations:** Mascot, Liverpool, Bents Basin, Camden, Campbelltown, Douglas Park, Picton, Bathurst (1903), Marrangaroo, Moss Vale.**Habitat****Habitat:** Disturbed sites, embankments, along roads, railways and riverbanks.**Altitude:** 0–1000 m**Annual rainfall:** 700–1200 mm**Typical local abundance:** Occasional–rare.**Vegetation:** Roadside herbaceous weeds, e.g. *Cirsium vulgare*, *Rumex*, *Senecio madagascariensis* also grassland.**Substrate:** Sandy and stony soil, disturbed, infertile. Watertable permanently low, intermittent, fresh.**Exposure:****Conservation****Conservation:** Weed of disturbed sites, not invasive of bushland.

Irenepharsus trypherus

BRASSICACEAE

Life history

Growth form: Herb to 1 m high, spreading to erect.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:** Less than 1 year.**Flowers:** White, February–April.**Fruit/seed:** Capsule (silique) 5–20 mm long, mature February. Seeds sticky when wet.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** CC SC.**Distribution Sydney area:** Between Minnamurra Falls and Nowra area.**Select locations:** Minnamurra Falls, Upper Kangaroo Valley, Barrengarry Creek.

Habitat

Habitat: Moist sheltered gullies. Moist rock walls of the gorge and gullies (Mills 1988).**Altitude:** 0–600 m **Annual rainfall:** above 1200 mm**Typical local abundance:** Rare to occasional.**Vegetation:** Rainforest. Ground stratum.**Substrate:** Rocky cliff face.**Exposure:**

Conservation

Conservation: Endemic to Illawarra region, rare. Minnamurra Falls is northern limit, last collected 1959 (Mills 1988). Coded 2RC by Briggs & Leigh (1988).*Lepidium africanum* *

BRASSICACEAE

Life history

Growth form: Herb to 70 cm high.**Vegetative spread:** No.**Longevity:** Annual or perennial.**Primary juvenile period:****Flowers:** Petals less than 0.8 mm long.**Fruit/seed:** Dehiscent (silicula) 2–3 mm long, with small seeds, mature April–December.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Naturalised exotic, native to Africa.**Botanical subregions:** NC CC SC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., N.T., S.A., W.A.**Distribution Sydney area:** Widespread.**Select locations:** Putty Road, Mt Colah, Cheltenham, Rockdale (1903), Mt Annan, Picton, Dapto, Albion Park, Orange, Hilltop.

Habitat

Habitat: Roadside, wasteland, regrowth woodland.**Altitude:** 0–300 m **Annual rainfall:** above 800 mm**Typical local abundance:** Frequent.**Vegetation:** Roadside weeds, grassland, shrubland — *Olea europea* subsp. *africana*. Ground stratum.**Substrate:** Clay soils from Wianamatta Shale, also disturbed sandstone sites. Soil fertile–infertile. Recorded on saline sites in western NSW (Semple 1993).**Exposure:**

Conservation

Conservation: Common weed, not invasive of bushland.

***Lepidium bonariense* ***

BRASSICACEAE

Life history

Growth form: Herb to 50 cm high.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period:

Flowers: White, March–December.

Fruit/seed: Capsule (silicula) 2–4 mm long, opening when ripe, at any time of year. Seeds 1.5 mm long.

Dispersal, establishment & growth: Diaspore: seed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to S America.

Botanical subregions: NC CC NT NWS CWS SWS NWP SWP NFWP; Qld, Vic., S.A., W.A.

Distribution Sydney area: Widespread on coast and western Sydney.

Select locations: Swansea (1938), Cowan, Belrose (P. Kodala pers. comm.), Roseville, Centennial Park, Bankstown, Richmond, Austral, Campbelltown, Wollongong, Albion Park.

Habitat

Habitat: Roadside, wet places near creeks and salt water.

Altitude: 0–100 m **Annual rainfall:** above 700 mm

Typical local abundance: Frequent–occasional.

Vegetation: With grass, roadside weeds, fresh wetland and estuarine, e.g. *Casuarina glauca*. Ground stratum.

Substrate: Sand, sandstone boulders and muddy alluvium. Soil fertile–infertile–very infertile. Watertable mostly high, moisture supply intermittent, brackish–fresh. Recorded on saline sites in western NSW (Semple 1993).

Exposure: Mid shade.

Conservation

Conservation: A common weed, probably not invasive of bushland.

***Lepidium campestre* ***

BRASSICACEAE

Field Cress

Life history

Growth form: Herb to 60 cm high.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period:

Flowers: White.

Fruit/seed: Capsule (silicula) 5–6 mm long.

Dispersal, establishment & growth: Diaspore: seed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: CC SC NT CT ST NWS; Vic., Tas.

Distribution Sydney area:

Select locations: Campbelltown (1903), Taralga (1914).

Habitat

Habitat:

Altitude: 0–900 m **Annual rainfall:** 700–800 mm

Typical local abundance:

Vegetation:

Substrate:

Exposure:

Conservation

Conservation: Rare weed.

Lepidium fasciculatum

BRASSICACEAE

Life history

Growth form: Herb to 60 cm high.**Vegetative spread:** No.**Longevity:** 1 year.**Primary juvenile period:****Flowers:** Petals very small or absent, August–December.**Fruit/seed:** Capsule (silicula) 3–4 mm long, opening when ripe, August–December. Seed 1.25 mm long.**Dispersal, establishment & growth:** Diaspore: seed. A cool season annual, abundant only in occasional years (Cunningham et al. 1981).**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** CC NT NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A., W.A.**Distribution Sydney area:** Coast, scattered, probably introduced by stock.**Select locations:** Wondabyne (1922), Flemington Saleyards.

Habitat

Habitat: Saleyards ?**Altitude:** 0–100 m**Annual rainfall:** above 800 mm**Typical local abundance:** Rare.**Vegetation:****Substrate:****Exposure:**

Conservation

Conservation: An inland species; occurrences near Sydney would certainly be casual introductions along rail or road (L. Johnson pers. comm.).*Lepidium hyssopifolium*

BRASSICACEAE

Peppergrass

Life history

Growth form: Herb to 50 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** Petals very small or absent, February.**Fruit/seed:** Capsule (silicula) 3–5 mm long, opening when ripe, February. Seed 1.5 mm long.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:** Foodplant of Black Swan *Cygnus atratus* (Barker & Vestjens 1989, 1990).

Distribution

Status/origin: Native.**Botanical subregions:** NT CT ?ST; Qld, Vic., Tas., S.A., N.Z.**Distribution Sydney area:** Bathurst–Carcoar.**Select locations:** Bathurst, Peelwood.

Habitat

Habitat:**Altitude:** 700 m**Annual rainfall:** 600–700 mm**Typical local abundance:****Vegetation:** Ground stratum.**Substrate:****Exposure:**

Conservation

Conservation: Rare, coded 3ECA+ by Briggs & Leigh (1988), but not conserved in Sydney area.

Lepidium peregrinum

BRASSICACEAE

Life history

Growth form: Herb to 40 cm high.**Vegetative spread:****Longevity:** 1 year.**Primary juvenile period:****Flowers:****Fruit/seed:** Capsule (silicula) 2.7 mm long.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NT CT.**Distribution Sydney area:** Blue Mountains.**Select locations:** No locations known.

Habitat

Habitat:**Altitude:****Annual rainfall:****Typical local abundance:****Vegetation:****Substrate:****Exposure:**

Conservation

Conservation: Regarded as extinct, probably due to heavy grazing, and coded 3X by Briggs & Leigh (1988).*Lepidium perfoliatum* *

BRASSICACEAE

Life history

Growth form: Herb 20–40 cm high.**Vegetative spread:** No.**Longevity:** Less than 5 years.**Primary juvenile period:****Flowers:** Yellow.**Fruit/seed:** Capsule (silicula) 3–4 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Exotic, native to Europe.**Botanical subregions:** CT ST; Qld, S.A.**Distribution Sydney area:** Campbelltown.**Select locations:** Campbelltown district (1903) only record for Sydney area.

Habitat

Habitat:**Altitude:** 0–100 m**Annual rainfall:** 750 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:**

Conservation

Conservation: Not naturalised in the Sydney area.

Lepidium pseudohyssopifolium

BRASSICACEAE

Peppercress

Life history

Growth form: Herb to 60 cm high.**Vegetative spread:****Longevity:** Annual or perennial.**Primary juvenile period:****Flowers:** Petals very small or absent.**Fruit/seed:** Capsule (silicula) 3 mm long, mature, February and July.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** NC CC SC ST CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A., W.A., N.Z.**Distribution Sydney area:** Illawarra coast.**Select locations:** Five Islands, Shellharbour, Kiama.

Habitat

Habitat:**Altitude:** 0–100 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Ground stratum.**Substrate:****Exposure:**

Conservation

Conservation: Rare, last specimen collected Shellharbour (1949), conservation status not known.*Lepidium pseudotasmanicum*

BRASSICACEAE

Life history

Growth form: Herb 20–40 cm high.**Vegetative spread:** No.**Longevity:** 1–2 years.**Primary juvenile period:****Flowers:****Fruit/seed:** Dehiscent (silicula) 3 mm long, mature, January.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:**

Distribution

Status/origin: Native.**Botanical subregions:** CC SC; Qld, Vic., Tas., W.A., N.Z.**Distribution Sydney area:** Coast.**Select locations:** Como, Emu Plains, Otford.

Habitat

Habitat:**Altitude:** 0–100 m**Annual rainfall:** above 700 mm**Typical local abundance:****Vegetation:****Substrate:****Exposure:**

Conservation

Conservation: Rare, last recorded Emu Plains (1915), conservation status not known.

***Lobularia maritima* ***

BRASSICACEAE

Sweet Alyssum

Life history**Growth form:** Herb 5–40 cm high.**Vegetative spread:****Longevity:** Perennial.**Primary juvenile period:****Flowers:** White, pink or purple, at any time of year.**Fruit/seed:** Capsule (silicula) 2–3 mm wide, 1-seeded, mature March–June.**Dispersal, establishment & growth:****Fire response:** Probably killed, flowering within 23 weeks of high-intensity fire 1/1994 at Lane Cove (P. Kubiak pers. comm.).**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Mediterranean. Introduced as garden plant.**Botanical subregions:** CC SC CT; Qld, Vic., S.A., W.A.**Distribution Sydney area:** Mainly coastal.**Select locations:** Paddington, Tamarama, Ashfield (1887), Little Bay, Wollongong, Albion Park, Kiama, Minnamurra River, Leura.**Habitat****Habitat:** Grassy area generally near sea. Found on old homestead site at Leura after fire.**Altitude:** 0–1000 m**Annual rainfall:** above 1000 mm**Typical local abundance:** Frequent.**Vegetation:** Grassy areas. Ground stratum.**Substrate:** Beach, roadsides, remnant gardens, sandy soils.**Exposure:****Conservation****Conservation:** Garden escape, not invasive of bushland.***Lunaria annua* ***

BRASSICACEAE

Honesty

Life history**Growth form:** Herb 50–100 cm high.**Vegetative spread:** No.**Longevity:** 2 years.**Primary juvenile period:****Flowers:** Bluish purple, September.**Fruit/seed:** Capsule (silicula) circular, 30–40 mm long, with seeds 7 mm diam.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to Europe. Introduced as ornamental, rarely naturalised.**Botanical subregions:** NT CT ST SWS; Vic.**Distribution Sydney area:** Oberon.**Select locations:** Oberon (1936).**Habitat****Habitat:****Altitude:** 1100 m**Annual rainfall:** 850 mm**Typical local abundance:****Vegetation:** Ground stratum.**Substrate:****Exposure:****Conservation****Conservation:** Widely cultivated as an ornamental, especially for dried arrangements of the silvery septa of the fruit, very rarely naturalised.

***Raphanus raphanistrum* ***

BRASSICACEAE

Wild Radish, Jointed Charlock

Life history

Growth form: Slender herb 15–50 cm high, much branched, with long rosette leaves, taproot wiry to stout but not fleshy.

Vegetative spread: No.

Longevity: Generally 1 year.

Primary juvenile period: 3–6 months.

Flowers: White or yellow, at any time. Insect-pollinated, syrphids and white butterflies showed strong preference for yellow flowers (Armstrong et al. 1982).

Fruit/seed: Indehiscent pod (siliquea) 1–5 cm long, breaking into one-seeded capsules during harvest, mature October–November. Seeds ovoid 1.5–4 mm long. Can produce up to 17 000 seeds per square metre (Dellow 1987).

Dispersal, establishment & growth: Diaspore: 1-seeded capsule. Dispersed by wind, water, animals and humans in mud, but principally through agriculture (Parsons & Cuthbertson 1992), mixed with cereal grain (Dellow 1987). Germination of above 1000 seeds per square metre recorded, throughout year, over a wide range of temperatures but germinates best with widely fluctuating temperatures (Dellow 1987). Emergence is greatly increased by cultivation, the buried seed stimulated by darkness and higher moisture. Soil-stored seedbank, 20–40% of seeds produced in any one year remain viable in the soil after 12 months (Dellow 1987), buried seed remains viable longer, some remain viable for up to 20 years (Parsons & Cuthbertson 1992). Generally a winter and spring-growing annual but with suitable conditions can grow and mature throughout the year (Dellow 1987).

Fire response:

Interaction with other organisms: Host to thrips, flea beetles, and other plant pests and diseases; can cause death of cattle and lambs (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Naturalised exotic, native to Europe. Reported naturalised in Sydney by 1867 (Parsons & Cuthbertson 1992).

Botanical subregions: NC CC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Widespread.

Select locations: Wondabyne, Terrey Hills, Royal Botanic Gardens (1902), Glenfield, Elderslie, Campbelltown, Shellharbour, Robertson (P. Kodela pers. comm.).

Habitat

Habitat: Margins of cultivated areas, roadsides, winter cereal crops; pastures (P. Kodela pers. comm.).

Altitude: 0–800 m **Annual rainfall:** above 700 mm

Typical local abundance: Frequent.

Vegetation: Weeds of waste areas. Ground stratum.

Substrate: Sandy–clay soils, basalt (P. Kodela pers. comm.). Principally on highly fertile, acid, nitrogenous soils (Parsons & Cuthbertson 1992).

Exposure: Full sun.

Conservation

Conservation: Major weed of winter cereal crops reducing crop yields, probably not invasive of bushland.

***Raphanus sativus* ***

BRASSICACEAE

Radish

Life history

Growth form: Herb 20–100 cm high, with fleshy edible taproot.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period: Less than 1 year.

Flowers: White–purple, October–November.

Fruit/seed: Capsule (siliquea) 2–6 cm long, not breaking into 1-seeded units at maturity like *R. raphanistrum*, mature October–November.

Dispersal, establishment & growth: Diaspore: seed, dispersed by humans; germinates readily in cultivation, within 7 days.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe. Introduced as crop plant and cultivated for its edible taproot, doubtfully naturalised.

Botanical subregions: CC CWS; Qld, Vic., Tas., S.A.

Distribution Sydney area:

Select locations: Cheltenham, Dundas, North Sydney (1916), Richmond (1916).

Habitat

Habitat: Self-sown in garden.

Altitude: 0–100 m **Annual rainfall:** above 700 mm

Typical local abundance: Rare.

Vegetation: Ground stratum.

Substrate: Garden soil.

Exposure:

Conservation

Conservation: Self-sown in gardens and wasteland, unlikely to persist.

Rapistrum rugosum *

BRASSICACEAE

Turnip Weed, Giant Mustard

Life history

Growth form: Herb 15–60 cm high.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period:

Flowers: Yellow, dark-veined, April–November.

Fruit/seed: Capsule (silicula) 5–10 mm long, breaking into upper segment 3–6 mm long with 1 large seed, and lower segment 3 mm long with 0–2 small seeds, mature November.

Dispersal, establishment & growth: Diaspore: seed.

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.

Botanical subregions: NC CC NT CT NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas.

Distribution Sydney area: Western Sydney.

Select locations: Liverpool (1964), Glenfield, Menangle, Razorback, Meadow Flat Creek.

Habitat

Habitat: Roadside and earthworks.

Altitude: 0–800 m **Annual rainfall:** 600–900 mm

Typical local abundance: Frequent.

Vegetation: With other wasteland weeds. Ground stratum.

Substrate: Clay soils from Wianamatta Shale, fertile. Watertable permanently low, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation:

Rorippa dictyosperma

BRASSICACEAE

Life history

Growth form: Herb 30–90 cm high.

Vegetative spread: Probably not.

Longevity: Perennial.

Primary juvenile period:

Flowers: White.

Fruit/seed: Capsule (siliqua) 25–60 mm long, mature January–February. Seeds not mucilaginous when wet.

Dispersal, establishment & growth:

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CT ST; Qld, Vic., Tas., W.A.

Distribution Sydney area: Upper Blue Mountains.

Select locations: Mt Wilson, Jenolan Caves (1900), Barbers Creek.

Habitat

Habitat: Edge of track.

Altitude: 800–1000 m

Annual rainfall: above 1000 mm

Typical local abundance: Rare.

Vegetation: Rainforest. Ground stratum.

Substrate: Probably basalt soil, fertile. Fertile soil, but not always basalt (L. Johnson pers. comm.). Watertable mostly high, moisture supply intermittent, fresh.

Exposure:

Conservation

Conservation: Conservation status unknown.

Rorippa gigantea

BRASSICACEAE

Life history

Growth form: Decumbent to erect herb to 120 cm high with sessile leaves.

Vegetative spread: No.

Longevity: 1 year.

Primary juvenile period: Less than 1 year.

Flowers: White, September–January.

Fruit/seed: Capsule (siliqua) 15–40 mm long, mature December–February. Seeds sticky.

Dispersal, establishment & growth: Diaspore: seed, probably animal/bird-dispersed.

Seedling recruitment after disturbance, possibly fire related.

Fire response: Probably killed.

Interaction with other organisms:

Distribution

Status/origin: Native.

Botanical subregions: NC CC SC NT CT ST; Qld, Vic., Tas., N.Z.

Distribution Sydney area: Widespread but localised.

Select locations: Culoul Range, Blacksmiths Creek, Mt Warrawolong, Patonga, Waterfall, Cataract Creek, Cambewarra, Blackheath, Bundanoon.

Habitat

Habitat: Edge of creeks, tracks, hillsides, disturbed sites.

Altitude: 0–700 m

Annual rainfall: above 1000 mm

Typical local abundance: Frequent.

Vegetation: Edge of rainforest, e.g. found with *Solanum* spp. Ground stratum.

Substrate: Moist sandy alluvial soils, possibly with clay influence, fertile. Not on the usual highly infertile sandstone soils (L. Johnson pers. comm.).

Exposure: Sheltered situations, light shade–full sun.

Conservation

Conservation: Conservation status unknown.

Rorippa laciniata

BRASSICACEAE

Life history**Growth form:** Herb to 40 cm high.**Vegetative spread:** Probably not.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** White, August–March.**Fruit/seed:** Capsule (silique) 15–40 mm long, opening when ripe, October–April. Seeds brown.**Dispersal, establishment & growth:** Diaspore: seed.**Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Native.**Botanical subregions:** NC CC SC NT ST NWS CWS SWS NWP SWP; Qld, Vic., S.A.**Distribution Sydney area:** Sydney and South Coast.**Select locations:** Cowan, Cheltenham, Cooks River, Austral, Mt Kembla, Whispering Gallery (Albion Park), Minnamurra Falls, Cambewarra.**Habitat****Habitat:** Rocky creeks.**Altitude:** 0–500 m**Annual rainfall:** above 800 mm**Typical local abundance:** Rare.**Vegetation:** Light break in rainforest, open-forest. Ground stratum.**Substrate:** Sandstone, shale derived soil, fertile–infertile. Watertable mostly high, moisture supply intermittent, fresh.**Exposure:** Sheltered situations; light shade.**Conservation****Conservation:** Rare, probably not well conserved. Vulnerable in Western Sydney (Benson & McDougall 1991).***Rorippa microphylla* ***

BRASSICACEAE

One-rowed Watercress

Life history**Growth form:** Decumbent aquatic or semi-aquatic, stems to 40 cm long.**Vegetative spread:** Stoloniferous.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** White, November–January.**Fruit/seed:** Capsule (silique) 15–30 mm long.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe, W Asia.**Botanical subregions:** CC NT CT ST; Vic., Tas., S.A.**Distribution Sydney area:** Sporadic.**Select locations:** Kiama (1955), Oberon (1955), Taralga, Berrima.**Habitat****Habitat:** Creekbed.**Altitude:** 500–1000 m**Annual rainfall:** above 800 mm**Typical local abundance:** Occasional–rare.**Vegetation:****Substrate:** Mud or shallow water. Watertable permanently high, moisture supply continuous, fresh.**Exposure:****Conservation****Conservation:**

***Rorippa nasturtium-aquaticum* ***

BRASSICACEAE

Watercress

Life history**Growth form:** Decumbent aquatic or semi-aquatic herb, stems hollow, to 60 cm long.**Vegetative spread:** Stoloniferous, stems root at nodes and spread.**Longevity:** Perennial.**Primary juvenile period:****Flowers:** White, November.**Fruit/seed:** Capsule (siliqua) 10–18 mm long, mature November–February.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:** Eaten by humans but may contain toxins if growing on edges of polluted waterways (e.g. pesticides and fertilisers) (P. Kodela pers. comm.).**Distribution****Status/origin:** Naturalised exotic, native to W Asia, Europe, N Africa. Cultivated for edible leaves.**Botanical subregions:** NC CC NT CT ST NWS CWS; Qld, Vic., Tas., N.T., S.A., W.A.**Distribution Sydney area:** Sydney suburban areas and Western Blue Mountains. Southern Highlands (P. Kodela pers. comm.).**Select locations:** Cheltenham, Bondi, Kogarah, Menangle Park, Glenquarry, Wombeyan Caves, Abercrombie Caves, Tuena Creek (1918).**Habitat****Habitat:** Creek banks and in slow-moving water.**Altitude:** 0–800 m**Annual rainfall:** above 700 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Wetland vegetation.**Substrate:** Sandy alluvium, infertile. Watertable permanently high, moisture supply continuous, fresh. Margins of Wingecarribee swamp in fertile conditions (P. Kodela pers. comm.). Recorded on saline sites in western NSW (Semple 1993).**Exposure:** Sheltered situations.**Conservation****Conservation:** Weed in some urban bushland creeks.***Rorippa palustris* ***

BRASSICACEAE

Yellow Cress, Marsh Watercress

Life history**Growth form:** Herb 20–100 cm high.**Vegetative spread:** Sometimes stoloniferous.**Longevity:** 1–2 years.**Primary juvenile period:****Flowers:** Yellow, December–January.**Fruit/seed:** Capsule (siliqua) 5–9 mm long, mature December–March, peak December.**Dispersal, establishment & growth:****Fire response:****Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe.**Botanical subregions:** NC CC SC CT ST NWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.**Distribution Sydney area:** Widespread.**Select locations:** Broadwater Swamp, Windsor, Shane Park, Nepean River (Menangle), Jenolan Caves (1899), Kowmung River, Macquarie River, Fitzroy Falls Reservoir (P. Kodela pers. comm.).**Habitat****Habitat:** River banks and in water.**Altitude:** 0–1000 m**Annual rainfall:** above 600 mm**Typical local abundance:** Frequent–occasional.**Vegetation:** Wetland and creekbank vegetation, e.g. with *Persicaria*, *Ranunculus*, *Juncus*, *Lythrum*.

Substrate: Water or wet sand, fertile–infertile. Watertable permanently high, moisture supply continuous, fresh.
Exposure: Sheltered situations.

Conservation:

Conservation

Sinapis alba *

BRASSICACEAE

White Mustard

Life history

Growth form: Herb, stems 30–80 cm high.
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow, February.
Fruit/seed: Capsule (silique) 20–40 mm long, mature February. Seeds spherical, 1.7–2.3 mm diam., 1–4 per cell, pungent-tasting.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Mediterranean and & W Asia. Introduced to Australia as a cultivated crop for its pungent-tasting seeds.
Botanical subregions: CC ST CWS SWP; Qld, Tas.
Distribution Sydney area: Razorback.
Select locations: Razorback (1968).

Habitat

Habitat: Roadmaking earthworks.
Altitude: 300 m **Annual rainfall:** 700 mm
Typical local abundance: Rare.
Vegetation:
Substrate: Roadmaking earthworks, clay soil, fertile.
Exposure:

Conservation

Conservation: Rare weed of cultivation.

Sinapis arvensis *

BRASSICACEAE

Charlock

Life history

Growth form: Herb 30–80 cm high, stems often purplish.
Vegetative spread: No.
Longevity: Annual.
Primary juvenile period:
Flowers: Yellow, September.
Fruit/seed: Capsule (silique) 20–60 mm long, opening when ripe. Seeds globular, 1–2 mm diam., 6–12 per cell.
Dispersal, establishment & growth: Diaspore: seed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe, Asia and N Africa.
Botanical subregions: NC CC NWS CWS SWS NWP SWP SFWP; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Glenfield.
Select locations: Glenfield (1954) only record.

Habitat

Habitat: Isolated patch in oat crop.
Altitude: 30 m **Annual rainfall:** 800 mm

Typical local abundance: Rare.
Vegetation: Patch in oat crop.
Substrate: Probably clay soils, fertile.
Exposure: No shade.

Conservation

Conservation: Occurs in more inland regions, accidental introductions near Sydney.

Sisymbrium irio**BRASSICACEAE**

London Rocket

Life history

Growth form: Herb 25–60 cm high.
Vegetative spread: No.
Longevity: 1–2 years.
Primary juvenile period:
Flowers: Yellow–pale yellow, August–September.
Fruit/seed: Capsule (silique) 2.5–6.5 cm long, opening when ripe. Seeds ovoid, 1 mm diam., about 40 per cell.
Dispersal, establishment & growth: Dispersal: seed, winter–spring-growing.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native NSW species, possibly introduced from western NSW by stock, first recorded 1963.
Botanical subregions: NC CC NWS CWS SWS NWP SWP NFWP SFWP; all mainland States, Europe.
Distribution Sydney area: Flemington Saleyards, sporadic.
Select locations: Narara Creek, Glenfield (1963), Narellan.

Habitat

Habitat: Rubbish tip, saleyards, very disturbed sites.
Altitude: 0–200 m **Annual rainfall:** above 700 mm
Typical local abundance: Frequent.
Vegetation: With *Alternanthera philoxeroides*, for example. Ground stratum.
Substrate: Watertable mostly high.
Exposure:

Conservation

Conservation: Occasionally apparently naturalised in very disturbed places.

Sisymbrium officinale* **BRASSICACEAE**

Hedge Mustard

Life history

Growth form: Herb to 90 cm high.
Vegetative spread: No.
Longevity: Less than 5 years.
Primary juvenile period:
Flowers: Yellow–pale yellow. October–November.
Fruit/seed: Capsule (silique) 1–2 cm long, opening when ripe, mature December. Seeds ellipsoid–ovoid, 1.5 mm long.
Dispersal, establishment & growth: Diaspore: seed, autumn–winter-growing weed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.
Botanical subregions: NC CC SC NT CT ST NWS CWS NWP SWP; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area:

Select locations: Epping, Flemington, Campbelltown, Picton, Jenolan Caves (1899), Mt Cameron, Orange, East Kangaloon (P. Kodela pers. comm.).

Habitat

Habitat: Various — disturbed sites, rubbish tips, pastures, moist forest.

Altitude: 0–1000 m

Annual rainfall: above 700 mm

Typical local abundance: Frequent.

Vegetation: Moist eucalypt forest, e.g. *Eucalyptus viminalis*–*E. radiata*. Ground stratum.

Substrate: Basalt, shale soils, fertile.

Exposure:

Conservation

Conservation: Widespread occasional weed; not in bushland except where severely disturbed (L. Johnson pers. comm.).

Sisymbrium orientale* **BRASSICACEAE**

Indian Hedge Mustard

Life history

Growth form: Herb 25–90 cm high.

Vegetative spread: No.

Longevity: 1–2 years.

Primary juvenile period:

Flowers: Yellow–pale yellow at any time, peak October.

Fruit/seed: Capsule (silique) 4–10 cm long, opening when ripe, mature January. Seed ovoid, 1 mm long, about 60 per cell.

Dispersal, establishment & growth: Diaspore: seed; an autumn–spring weed, prevalent in years of high winter–spring rainfall (Cunningham et al. 1981).

Fire response:

Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to W Asia, Mediterranean.

Botanical subregions: NC CC SC CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.

Distribution Sydney area: Western Sydney, Bathurst. Southern Highlands (P. Kodela pers. comm.).

Select locations: Wondabyne, Royal Botanic Gardens (1902), Flemington Saleyards, Glenfield, Camden, Picton, Shellharbour, Bathurst, Meadow Flat, Moss Vale.

Habitat

Habitat: Stock pens, roadside, rubbish tip.

Altitude: 0–800 m

Annual rainfall: above 600 mm

Typical local abundance: Occasional.

Vegetation: Ground stratum, e.g. with pasture grasses and other herbs.

Substrate: Disturbed sites. Fertile soil.

Exposure:

Conservation

Conservation: Weed of disturbed soil, not invasive of bushland.

Turritis glabra* **BRASSICACEAE**

Tower Mustard

Life history

Growth form: Biennial herb 60–120 cm high.

Vegetative spread:

Longevity: 2 years.

Primary juvenile period:

Flowers: Pale yellow, October.

Fruit/seed: Capsule (silique) 3–7 cm long.

Dispersal, establishment & growth: Diaspore: seeds.

Fire response:**Interaction with other organisms:****Distribution****Status/origin:** Naturalised exotic, native to Europe.**Botanical subregions:** NT CT ST; Vic.**Distribution Sydney area:** Jenolan Caves.**Select locations:** Jenolan Caves (1899), only record for Sydney area.**Habitat****Habitat:****Altitude:** 1000 m**Annual rainfall:** 900 mm**Typical local abundance:****Vegetation:** Ground stratum.**Substrate:****Exposure:****Conservation****Conservation:** Rarely naturalised.***Buddleja davidii* *****BUDDLEJACEAE**

Butterfly Bush

Life history**Growth form:** Shrub 1.5–3 m high.**Vegetative spread:** No.**Longevity:** 10–20 years.**Primary juvenile period:** 2 years.**Flowers:** White to lilac-purple, May–October, probably butterfly-pollinated.**Fruit/seed:** Brownish capsule 5–10 mm long, 2-valved with many seeds.**Dispersal, establishment & growth:** Diaspore: seed, wind-dispersed locally, establishes in moist rocky crevices. Possibly also water-dispersed (Carr et al. 1992).**Fire response:** Possibly killed after high-intensity fire (P. Kubiak pers. comm.).**Interaction with other organisms:****Distribution****Status/origin:** Exotic, native to China and Japan, introduced as ornamental. Widely cultivated, persists in old gardens, naturalised in Blue Mountains.**Botanical subregions:** NT CT ST.**Distribution Sydney area:** Upper Blue Mountains.**Select locations:** Lithgow (1979), also Katoomba, Leura (1993).**Habitat****Habitat:** Naturalised on cliffs, railway cuttings, disturbed sites.**Altitude:** 0–1000 m**Annual rainfall:** above 1200 mm**Typical local abundance:** Frequent.**Vegetation:** Eucalypt open-forest, e.g. *Eucalyptus radiata*, *E. cypelloarpa*.**Substrate:** Cliffs and cuttings, sandstone, infertile soil. Watertable mostly high, moisture supply intermittent, fresh.**Exposure:** Full sun–mid shade.**Conservation****Conservation:** Naturalised in upper Blue Mountains, possibly increasing in abundance, potential problem in urban bushland and bushland margins.***Buddleja madagascariensis* * (Nicodemia madagascariensis)****BUDDLEJACEAE**

Butterfly Bush

Life history**Growth form:** Straggly shrub 1.5–4 m high.**Vegetative spread:** Vegetative (anon 1991).**Longevity:****Primary juvenile period:****Flowers:** Orange, May–October.

Fruit/seed: Globose berry, 5 mm long, blue-violet, with many seeds.
Dispersal, establishment & growth: Diaspore: berry, dispersal of fruit not known. Vegetative fragments dispersed in garden refuse or dispersed by gravity or water (Anon 1991).
Fire response: Resprouted from base after high-intensity fire 1/1994 at Narrabeen (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Madagascar. Introduced as an ornamental, widely cultivated, persisting in old gardens, more or less naturalised in a few disturbed areas.

Botanical subregions: NC CC SC.

Distribution Sydney area: Sydney suburbs.

Select locations: Wisemans Ferry, Cheltenham, Narrabeen, Ermington, Nowra (1920).

Habitat

Habitat: Disturbed sites in moist forest, urban bush.

Altitude: 0–200 m **Annual rainfall:** above 750 mm

Typical local abundance: Occasional.

Vegetation: Moist eucalypt forest, e.g. with *Syncarpia glomulifera*, *Angophora costata*, *Eucalyptus pilularis*.

Substrate: Shale, laterite soils, fertile, watertable mostly high.

Exposure: Full sun.

Conservation

Conservation: Minor weed.

Index to *Ecology of Sydney plant species 2*

Scientific names are in bold type, synonyms or misapplied names are in italics and family names are in upper case. Common names are in roman type.

A

- Acanthospermum**
australe * 800
- Achillea**
distans
subsp. tanacetifolia * 800
millefolium * 801
- Actites**
megalocarpa 801
- Adenostemma**
lavenia var. *lavenia* 802
- Ageratina**
adenophora * 802
riparia * 803
- Ageratum**
houstonianum * 804
- Ambrosia**
artemisiifolia * 804
confertifolia 806
psilostachya * 805
tenuifolia * 806
- Ammobium**
alatum 806
- Amsinckia**
calycina * 956
hispida 956
intermedia * 957
- Anchusa**
arvensis * 957
- Anredera**
cordifolia * 949
- Anthemis**
arvensis * 807
cotula * 807
- Arctium**
lappa * 808
minus * 808
- Arctotheca**
calendula * 809
nivca 809
populifolia * 809
- Arctotis**
australiensis 860
stoechadifolia * 810
 White 810
- Arrhenechthites**
mixta 811
- Artemisia**
verlotiorum * 811

Artichoke

- Globe 861
 Jerusalem 876

Aster

- novi-belgii* * 812
subulatus * 812

ASTERACEAE 800-947

Austrocynoglossum *latifolium* 958

Avicennia

- marina* subsp. *australasica* 948
 AVICENNIACEAE 948

B

Baccharis

- halimifolia* * 813

Balsam 949

BALSAMINACEAE 949

Barbarea

- verna* * 967

BASELLACEAE 949

Bauera

- capitata* 950
microphylla 951
rubroides 951

BAUERACEAE 950-951

Bears-ear 860

Beauty-heads

- Lemon 827

BERBERIDACEAE 952-953

Berberis

- aristata* * 952
darwinii * 952

Bidens

- pilosa* * 813
subalternans * 814
tripartita * 814

BIGNONIACEAE 953-956

Bindyi 931

Bitou Bush 846

Bittercress

- Common 973
 Wood 972

Bogan Flea 829

Bonesed 847

Borage 959

BORAGINACEAE 956-967

Borago

- officinalis* * 959

Bottle-daisy

Blue 885

Brachycome*aculeata* 815*angustifolia*var. *angustifolia* 816var. *heterophylla* 816*decipiens* 817*diversifolia*var. *dissecta* 817var. *diversifolia* 818*formosa* 818*graminea* 819*heterodonta* var. *heterodonta* 819*microcarpa* 820*multifida*var. *dilatata* 820var. *multifida* 821*procumbens* 821*ptychocarpa* 822*rigidula* 822*scapiformis* 823*scapigera* 823*spathulata* 823*stuartii* 824**Bracteantha***bracteata* 824*viscosa* 825**Brassica***fruticulosa* * 968*junceae* * 968*rapa* subsp. *silvestris* * 969*tournefortii* * 969**BRASSICACEAE** 968–994

Buchan Weed 979

Buddleja*davidii* * 994*madagascariensis* * 994**BUDDLEJACEAE** 994–995**Bugloss**

Viper's 962

Wild 957

Buglossoides*arvensis* * 959**Burdock**

Common 808

Greater 808

Burr

Bathurst 947

Cockle 946

Noogoora 946

South American 946

White Daisy 828

Burr-daisy

Purple 828

Rough 831

Tufted 831

Yellow 830

Burweed

Lawn 931

Bushy Starwort 812

Busy Lizzie 949

Butterfly Bush 994

Button Weed 930

Buttons

Scaly 888

Water 856

Yellow 848

C**Cakile***edentula* * 970*maritima* * 970**Calendula***arvensis* * 825*officinalis* * 826*palaestina* * 826**Calocephalus***citreus* 827**Calomeria***amaranthoides* 827**Calotis***cuneifolia* 828*dentex* 828*glandulosa* 829*hispidula* 829*lappulacea* 830*scabiosifolia* var. *integrifolia* 831*scapigera* 831**Camelina***alyssum* * 971

Cape Weed 809

Capsella*bursa-pastoris* * 971**Cardamine***flexuosa* * 972*gunnii* 972*hirsuta* * 973*lilacina* 974*paucijuga* 974

species Y 975

Cardaria*draba* * 975**Carduus***nutans* subsp. *nutans* * 832*pycnocephalus* * 832*pycnocephalus* 833*tenuiflorus* * 833

Carrot Weed 855

Carthamus*lanatus* * 833*tinctorius* * 834

Cassinia

- aculeata* 835
- arcuata* 835
- aureonitens* 836
- compacta* 837
- cunninghamii* 837
- denticulata* 838
- laevis* 838
- leptocephala* subsp. *leptocephala* 839
- longifolia* 839
- quinquefaria* 840
- species D* 840
- Sticky* 841
- trinerva* 841
- uncata* 841

Cat's Claw Creeper 953

Catsear 882

Smooth 881

Celmisia

- longifolia* species complex 842

Centaurea

- australis* 933
- calcitrapa* * 842
- melitensis* * 843
- solstitialis* * 843

Centipeda

- cunninghamii* 844
- minima* var. *minima* 845

Chamomile

- Corn 807

Chamomilla

- suaveolens* 891

Charlock 991

- Jointed 986

Chicory 849**Chinese Shrub** 835**Chondrilla**

- juncea* * 845

Chrysanthemoides

- monilifera*
 - subsp. *rotundata* * 846
- monilifera* *
 - subsp. *monilifera* 847

Chrysocephalum

- apiculatum* 848
- semipapposum* 848

Cichorium

- intybus* * 849

Cirsium

- vulgare* * 850

Cobblers Pegs 813**Cobbler's Tack** 869**Conringia**

- orientalis* * 976

Conyza

- albida* * 851
- bilbaoana* * 851
- bonariensis* * 852

canadensis var. *canadensis* * 853

parva * 853

Coreopsis 854

- lanceolata* * 854

Coronopus

- didymus* * 976

Cosmos 854

- bipinnatus* * 854

Cotula

- alpina* 855
- Alpine* 855
- australis* 855
- Common* 855
- coronopifolia* * 856
- longipes* 886

Cough Bush 838**Craspedia**

- canens* 857
- variabilis* 857

Crassocephalum

- crepidioides* * 858

Crepis

- capillaris* * 858
- foetida* subsp. *vulgare* * 859
- setosa* * 859

Cress

- Field 981
- Hoary 975
- Mountain 978
- Yellow 990

Cretan Weed 875**Crofton Weed** 802**Crownbeard** 939**Cryptostemma**

- calendula* 809

Cudweed

- Creeping* 866
- Jersey* 910
- Purplish* 871
- Spoon* 933
- Star* 867
- White* 938

Cymbonotus

- lawsonianus* 860
- lawsonianus* 860
- preissianus* 860

Cynara

- scolymus* * 861

Cynoglossum

- australe* 960
- latifolium* 958
- suaveolens* 960

D**Daisy**

- Beach* 809
- Cut-leaved* 820, 821

Field 817
 Hill 815
 Large Copper-wire 909
 Large-headed 817, 818
 Michaelmas 812
 Oxeye 888
 Showy Copper-wire 910
 Snow 842
 Sticky 802
 Western New Holland 945
 White Paper 878

Daisy Bush
 Blush 898
 Rough 893
 Silky 896
 Sticky 895
 Dandelion 935
 Cape 809

Delairea
odorata * 861
 Dimorphotheca
pluvialis * 862
 Diplotaxis
muralis * 977
 Dittrichia
graveolens * 862

Dogwood
 White 906
 Dolly Bush 835
 Drabastrum
alpestre 978

E

Echinops
sphaerocephalus * 863
 Echium
lycopsis 961
plantagineum * 961
vulgare * 962
 Eclipta
platyglossa 863
 Ehretia
acuminata var. *acuminata* 962
 Enydra
fluctuans 864
 Epaltes
australis 864
 Erechites
valerianifolia * 865
 Erigeron
karvinskianus * 866
 Erophila
verna
 subsp. *praecox* * 978
 subsp. *verna* * 979
 Euchiton
gymnocephalus 866

involucratus 867
 Euryops
chrysanthemoides * 867
 Everlasting
 Button 879
 Clustered 848
 Common 848
 Golden 824
 Pale 879
 Satin 878
 Sticky 825
 Tree 907

F

Facelis
retusa * 868
 Feverfew 934
 Fiddleneck
 Common 957
 Fireweed 921
 Brazilian 865
 Cotton 923
 Hill 917
 Purple 811
 Flame Vine 955
 Flatweed 882
 White 881
 Flaxweed
 Stinking 972
 Fleabane
 Bony-tip 866
 Canadian 851, 853
 Flaxleaf 852
 Tall 851
 Forget-me-not 966
 Australian 965
 Wood 967
 Fuzzweed 941

G

Galinsoga
parviflora * 868
Gamolepis
chrysanthemoides 867
 Gazania
rigens * 869
 Glossogyne
tannensis 869
tenuifolia 869
 Gnaphalium
americanum * 870
calviceps * 871
candidissimum 938
coarctatum 871
gymnocephalum 866
involucratum 867
lutco-album 910

pensylvanicum * 872

polycaulon 872

sphaericum 873

Goldenrod 929

Grass Cushion 883

Greater Beggar's Ticks 814

Grindelia

camporum var. *australis* * 873

Groundsel 926

Variable 918, 919

Groundsel Bush 813

Guizotia

abyssinica * 874

Gymnocoronis

spilanthoides * 874

H

Hairy Brassica 979

Halgania

brachyrhyncha 963

Hare's Ear 976

Hawkbit

Lesser 886

Hawksbeard

Smooth 858

Stinking 859

Hawkweed

Yellow 936

Hawkweed *Picris* 908

Hedypnois

rhagadioloides subsp. *cretica* * 875

Helianthus

annuus * 875

tuberosus * 876

Helichrysum

adenophorum var. *waddelliae* 876

adnatum 905

apiculatum 848

argophyllum 906

bracteatum 824

calvertianum 877

collinum 877

dendroideum 907

diosmifolium 906

elatum 878

leucopsidium 878

rosmarinifolium 908

rutidolepis 879

scorpioides 879

semipapposum 848

viscosum 825

Heliotrope

Blue 963

Common 964

Heliotropium

amplexicaule * 963

europaeum 964

Helipterum

albicans var. *graminifolium* 890

albicans 889

anthemoides 911

australe 938

pygmaeum 911

Helminthotheca

echioides * 880

Hemizonia

pungens * 880

Hirschfeldia

incana * 979

Honesty 985

Honeysuckle

Cape 955

Humeca

elegans 827

Hypochoeris

glabra * 881

microcephala var. *albiflora* * 881

radicata * 882

I

Impatiens

walleriana * 949

Incense Plant 827

Indian Weed 927

Irenephrasus

trypherus 980

Isoetopsis

graminifolia 883

Ivy

Cape 861

J

Jalap 949

Jo-jo 931

Dwarf 930

K

Koda 963

L

Lactuca

saligna * 883

serriola * 884

Lagenifera

bellioides 928

gracilis 884

sp. *A* var. *B* 929

sp. *B* 928

stipitata 885

Lagenophora

Common 885

Slender 884

Lamb's Tail 949

Leontodon

taraxacoides subsp. *taraxacoides* * 886

Lepidium

- africanum* * 980
- bonariense* * 981
- campestre* * 981
- draba* 975
- fasciculatum* 982
- hyssopifolium* 982
- peregrinum* 983
- perfoliatum* * 983
- pseudohyssopifolium* 984
- pseudotasmanicum* 984

Leptinella

- longipes* 886

Leptorhynchus

- elongatus* 887
- nitidulus* 887
- squamatus* subsp. A 888

Lettuce

- Prickly 884
- Willow-leaved 883

Leucanthemum

- vulgare* subsp. *maximum* * 888

Leucochrysum

- albicans*
 - subsp. *albicans* var. *albicans* 889
 - subsp. *albicans* var. *tricolor* 889
- graminifolium* 890

Leuzea

- australis* 933

Lithospermum

- arvense* 959

Lobularia

- maritima* * 985

Lunaria

- annua* * 985

Lycopsis

- arvensis* 957

M**Macfadyena**

- unguis-cati* * 953

Madeira Vine 949**Madia**

- sativa* * 890

Mahonia

- leschenaultii* * 953

Maltese Cockspur 843**Mangrove**

- Grey 948

Marigold

- Burr 814
- Cape 862
- Dwarf 912
- Field 825
- Palestine 826

Matricaria

- matricarioides* * 891
- perforata* 937

Mayweed

- Scentless 937
- Stinking 807

Melanthra

- biflora* 891

Microseris

- lanceolata* 892

Mist Flower 803**Mugwort** 811**Musk** -

- Native 893

Mustard

- Giant 987
- Hedge 992
- Indian 968
- Indian Hedge 993
- Tower 993
- Treacle 976
- White 991

Myosotis

- australis* 965
- caespitosa* * 965
- discolor* * 966
- exarrhena* 966
- suavcolens* 966
- sylvatica* * 967

N**Nicodemia**

- madagascariensis* 994

Niger Seed 874**Nut-heads**

- Spreading 864

O**Olearia**

- argophylla* 893
- asterotricha* 893
- burgessii* 894
- chrysophylla* 894
- cordata* 895
- elliptica* 895
- erubescens* 896
- glandulosa* 896
- lirata* 902
- megalophylla* 897
- microphylla* 897
- myrsinoides* 898
- nernstii* 898
- oliganthema* 899
- phlogopappa* 899
- quercifolia* 900
- ramosissima* 900
- ramulosa* 901
- rosmarinifolia* 901
- stellulata* 902
- suffruticosa* 902

tenuifolia 903

tomentosa 903

viscidula 904

Onopordum

acanthium subsp. *acanthium* * 904

Osteospermum

ecklonis * 905

Ox-tongue 880

Ozothamnus

adnatus 905

argophyllus 906

diosmifolius 906

ferrugineus 907

rosmarinifolius 908

P

Pandorea

pandorana 954

Peppercress 982, 984

Picris

echioides 880

hieracioides * 908

Pigmy Sunray 911

Pilliga Posy 818

Pineapple Weed 891

Pitch-forks 813

Pitchweed 890

Podolepis

canescens 909

hieracioides 909

jaccoides 910

Potato Weed 868, 964

Pseudognaphalium

luteoalbum 910

Pyrostegia

venusta * 955

R

Radish 987

Wild 986

Ragweed

Annual 804

Lacy 806

Perennial 805

Ragwort 918

Rantil 874

Raphanus

raphanistrum * 986

sativus * 986

Rapistrum

rugosum * 987

Rhodanthe

anthemoides 911

pygmaea 911

Rocket

London 992

Sea 970

Wall 977

Roldana

petasitis * 912

Rorippa

dictyosperma 987

gigantea 988

laciniata 989

microphylla * 989

nasturtium-aquaticum * 990

palustris * 990

S

Safflower 834

Salsify 937

Schkuhria

pinnata var. *abrotanoides* * 912

Sea Rocket 970

American 970

Senecio

amygdalifolius 913

anacampserotis 913

bipinnatisectus 914

biserratus 914

crassiflorus * 915

diaschides 915

glomeratus 916

hispidulus

var. *dissectus* 916

var. *hispidulus* 917

jacobaea * 918

lautus

subsp. *dissectifolius* 918

subsp. *lanceolatus* 919

subsp. *maritimus* 919

linearifolius 920

macranthus 920

madagascariensis * 921

mikanioides 861

minimus 922

petasitis 912

pterophorus * 922

quadridentatus 923

species E 923

tamioides * 924

tenuiflorus 924

vagus

subsp. *eglandulosus* 925

velleioides 926

vulgaris * 926

Sheepweed 960

Shepherd's Purse 971

Sifton Bush 835

Sigesbeckia

orientalis subsp. *orientalis* 927

Silver Shrub 893

Silybum

marianum * 927

Sinapis

- alba* * 991
- arvensis* * 992

Sisymbrium

- irio* 992
- officinale* * 992
- orientale* * 993

Skeleton Weed 845**Sneeze Weed**

- Common 844
- Spreading 845

Snow Bush 897**Solenogyne**

- bellioides* 928
- dominii* 928
- gunnii* 929

Solidago

- canadensis* var. *scabra* * 929

Soliva

- anthemifolia* * 930
- pterosperma* 931
- sessilis* * 931

Sonchus

- asper*
 - subsp. *glaucescens* * 931
- hydrophilus* 932
- megalocarpus* 801
- oleraceus* * 932

Sowthistle

- Common 932
- Native 932
- Prickly 931

Sphaeromorpha

- australis* 864

Spikeweed 880**Stemmacantha**

- australis* 933

Stinking Roger 934**Stinkwort** 862**Stuartina**

- muelleri* 933

Sunflower

- Common 875

Sweet Alyssum 985**Swinecress**

- Lesser 976

T**Tagetes**

- minuta* * 934

Tanacetum

- parthenium* * 934
- vulgare* * 935

Tansy 935**Tansyleaf Milfoil** 800**Taraxacum**

- officinale* * 935

Tarweed 890**Tea**

- Senegal 874

Tecoma 956

- capensis* * 955
- stans* * 956

Temple Plant 874**Thickhead** 858**Thistle**

- Cockspur 843
- Dune 801
- Globe 863
- Nodding 832
- Saffron 833
- Scotch 904
- Slender 832
- Spear 850
- St Barnaby's 843
- Star 842
- Variegated 927
- Winged Slender 833

Tolpis

- umbellata* * 936

Tragopogon

- porrifolius* * 937

Tripleurospermum

- inodorum* * 937

Triptilodiscus

- pygmaeus* 938

Turnip 969

- Mediterranean 970
- Twiggy 968

Turnip Weed 987**Turritis**

- glabra* * 993

Twin-heads 863**V****Vellereophyton**

- dealbatum* * 938

Verbesina

- encelioides* subsp. *encelioides* * 939

Vernonia

- cinerea*
 - var. *cinera* 939

Vittadinia

- cervicularis*
 - var. *cervicularis* 940
 - var. *subcervicularis* 940
- cuneata*
 - var. *cuneata* forma *cuneata* 941
 - var. *cuneata* forma *minor* 941
- dissecta* var. *dissecta* 942
 - form *a* 941
 - form *b* 941
- gracilis* 942

hispidulavar. **hispidula** 943var. **setosa** 943*hispidula* 943**muelleri** 944**pustulata** 944sp. *E* 942sp. *F* 945sp. *G* 944sp. *H* 944**sulcata** 945**tenuissima** 945**W**

Wallaby Weed 904

Watercress 990

Marsh 990

One-rowed 989

*Wedelia**biflora* 891

White Weed 975

Whitlow Grass 978

Wild Aster 812

Wintercress 967, 968

Wonga Wonga Vine 954

Woodcress

Hairy 973

Wormwood

Chinese 811

X**Xanthium***cavanillesii* * 946*chinese* 946*occidentale* * 946*pungens* 946*spinosum* * 947**Y**

Yarrow 801



Royal Botanic Gardens Victoria



RBG00012614

125000
125000

Natural Vegetation
of the
DENILQUIN-BENDIGO
(New South Wales)
1:250 000 Map Sheet

Herbarium
[125000]

Marianne F. Porteners

125000

DENILIQVIN-BENDIGO

1:250 000 VEGETATION SERIES

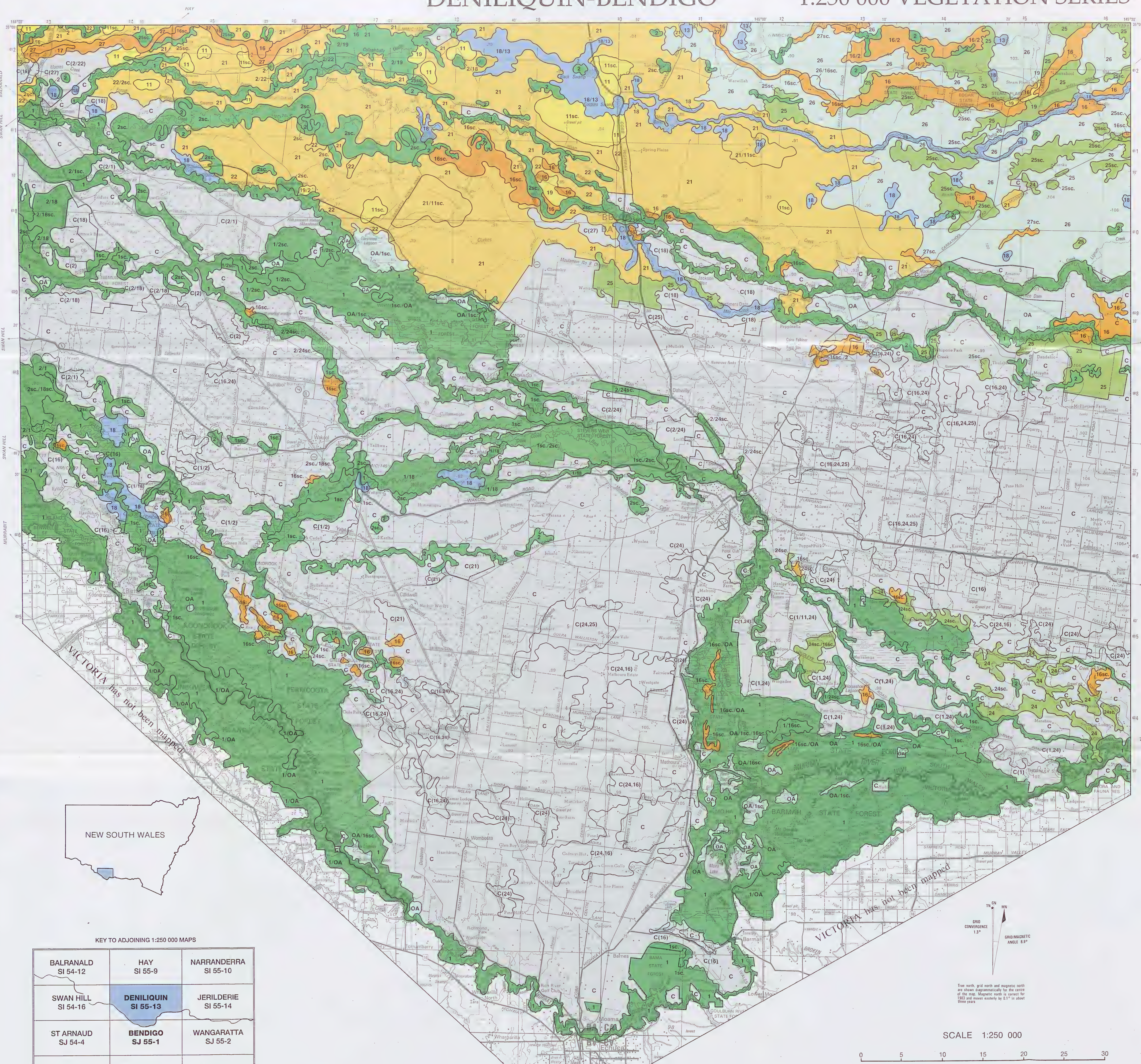
Natural Vegetation
of the
DENILIQVIN-BENDIGO
(New South Wales)
1:250 000 Map Sheet

Marianne F. Porteners

Descriptions of the plant communities are given
in *Cunninghamia* 3(1) 1993Compiled and prepared at the
National Herbarium of New South Wales

ROYAL BOTANIC GARDENS SYDNEY

Understanding the ecology of our native plants



MAP UNIT DESCRIPTIONS

No.	Plant Community	Main Species	Structure	Habitat
1	Riverine Forest	<i>Eucalyptus camaldulensis</i>	open forest	Adjacent to rivers on levees and flats of grey clay soil.
2	Black Box Woodland	<i>Eucalyptus largiflorens</i>	woodland - open woodland	On river floodplains, low-lying areas and creek lines on grey clay soils.
24	Grey Box Woodland	<i>Eucalyptus microcarpa</i> , <i>Allocasuarina luehmannii</i>	woodland - open woodland	Elevated flats and rises of the Murray River floodplains and brown earths and clay.
25	<i>Acacia pendula</i> Woodland	<i>Acacia pendula</i>	woodland - open woodland	Level to depressed plains in the east on grey and brown clays and red earths.
16	<i>Callitris</i> Mixed Woodland	<i>Callitris glaucochylla</i> , <i>Callitris gracilis</i> subsp. <i>murrayensis</i> (south of Deniliquin)	woodland - isolated clumps	Sandy rises of old source-bordering dunes on red and brown sands and loams.
17	<i>Acacia melvillei</i> Woodland	<i>Acacia melvillei</i>	woodland - shrubland	Undulating plains and low rises on red-brown clay to sandy loam.
27	Prior Stream Remnant Woodland	<i>Callitris glaucochylla</i> , <i>Hakea leucophaea</i> , <i>Hakea taphroscarpa</i>	open woodland - isolated trees	Sandy ridges of old prior stream beds in the south-east on gravelly to sandy soils.
19	Old Man Saltbush	<i>Atriplex nummularia</i>	chenopod shrubland - open chenopod shrubland	Level to depressed plains on grey or brown clays and often in low-lying situations with community 2.
11	Bladder Saltbush	<i>Atriplex vesicaria</i>	chenopod shrubland - open chenopod shrubland	Level to depressed alluvial plains on deep grey, cracking clays to red clay-loam.
12	<i>Sclerostegia tenuis</i>	<i>Sclerostegia tenuis</i> , <i>Disphyma crassifolium</i> subsp. <i>clavellatum</i>	closed - open chenopod shrubland	Saline flats and depressions in the west on clay soils.
21	Cottonbush	<i>Maireana aphylla</i>	chenopod shrubland - sparse chenopod shrubland	Depressed alluvial plains in the south-west on grey clay soils.
22	Dillon Bush	<i>Nitroaria billardieri</i>	shrubland - sparse shrubland	Disturbed situations on plains, floodplains and dry lakebeds. Often associated with 2, 18 and 21.
26	White-top Grassland	<i>Danthonia caespitosa</i>	grassland open grassland	Level alluvial plains in the east on grey to brown clay soils.
OA	Open Areas	various grasses, herbs and forbs	grassland - forbland	Highly disturbed areas usually on heavy soils.
13	Canegrass	<i>Eragrostis australasica</i>	tussock grassland	Depressions and low-lying areas on heavy grey clays.
18	Lignum and <i>Chenopodium nitriaceum</i>	<i>Muehlenbeckia floruenta</i> , <i>Chenopodium nitriaceum</i>	closed - open shrubland	Infrequently flooded channels, depressions and river flats on heavy grey cracking clays.
C	Cleared and/or Cropped	Native vegetation has largely been removed for agricultural or urban development but remnant vegetation of varying sizes and condition may remain. Where possible pre-cleared vegetation and remnants are indicated in brackets following C.		
sc.	scattered	plants are scattered		

Present vegetation as at January 1993. Clearing marked from LANDSAT TM imagery dated 01-01-1993 to 10-01-1993.

Topographic base from Deniliquin SI 55-13 and Bendigo SJ 55-1 1:250 000 map sheets are Crown Copyright and have been reproduced with the permission of the General Manager, Australian Survey and Land Information Group, Department of Administrative Services, Canberra, ACT.

This project was jointly funded by the Natural Resources Management Strategy of the Murray-Darling Basin Commission, and the Royal Botanic Gardens, Sydney.

PLANT COMMUNITIES OF THE DENILIKUIN-BENDIGO 1:250 000 MAP SHEET

Community 1	Riverine Forest
Structure: open forest # and ##	
Main species: <i>Eucalyptus camaldulensis</i> (River Red Gum)	
Associated species: <i>Acacia stenophylla</i> , <i>Muehlenbeckia florulenta</i> , <i>Eucalyptus largiflorens</i> , <i>Eucalyptus microcarpa</i> , <i>Chenopodium nitriaceum</i> , <i>Juncus ingens</i> , <i>Excarpus strictus</i> , <i>Acacia salicina</i> , <i>‘Lycium ferocissimum</i> .	
Ground-cover species: <i>Pratia concolor</i> , <i>Glinus lotoideis</i> , <i>Oxalis perennans</i> , <i>Centipedia cunninghamii</i> , <i>Paspalidium jubiflorum</i> , <i>Alternanthera denticulata</i> , <i>Chamaeocye drummondii</i> , <i>Cotula australis</i> , <i>Marsilea drummondii</i> , <i>Carex appressa</i> , <i>Poa fordeana</i> , <i>Agrostis avenacea</i> , <i>‘Cotula bipinnata</i> , <i>‘Stellaria media</i> , <i>‘Solanum nigrum</i> , <i>‘Sonchus oleraceus</i> .	
Landform: River and creek levees and adjacent flats, channelled plains and other areas subject to frequent or periodic flooding.	
Soils: Heavy grey, brown and red clays.	
Occurrence: This community occurs along the major river systems of the Murray and Edward-Wakool Rivers and other rivers and creeks throughout the mapped area. <i>Eucalyptus camaldulensis</i> will occur with Black Box wherever periodic flooding occurs. Dense stands of <i>Eucalyptus camaldulensis</i> occur along the Murray and on its adjacent floodplain, particularly in the Bamnah and Milewa State Forests, which are internationally recognised wetland habitats (Finlayson & Moser 1991). Rare hybrids of <i>Eucalyptus camaldulensis</i> and <i>E. largiflorens</i> occur between Barham and Swan Hill. <i>Eucalyptus microcarpa</i> (Grey Box) forms extensive stands within <i>Eucalyptus camaldulensis</i> forests in the Deniliquin area. In Werai State Forest north-west of Deniliquin, <i>Eucalyptus microcarpa</i> reaches open forest proportions. Within the Murray floodplain, higher areas of red-brown earths or sands occur, carrying much-cleared woodlands of <i>Callitris gracilis</i> subsp. <i>murrayensis</i> (Murray Cypress Pine) or <i>C. glaucophylla</i> (White Cypress Pine) (See Community 16). A small population of <i>Eucalyptus leucocylon</i> subsp. <i>pruinosa</i> (unmapped) exists just north of Barham, adjacent to <i>Eucalyptus camaldulensis</i> and <i>E. largiflorens</i> woodland and growing on grey-brown alluvial soil.	
A shrub layer is normally absent in this community, with leaf and branch litter dominating the ground layer. Shrubs, if present, may include <i>Muehlenbeckia florulenta</i> (Lignum), <i>Chenopodium nitriaceum</i> and <i>‘Lycium ferocissimum</i> . <i>Muehlenbeckia florulenta</i> and <i>Eragrostis australasica</i> may occur in intermittently flooded channels within the floodplain while areas of semi-permanent still water support rushlands of <i>Typha</i> spp., <i>Phragmites australis</i> , <i>Juncus</i> spp. and <i>Eleocharis</i> spp. The herbaceous layer varies seasonally and, as well as the species listed, may include <i>Rumex</i> , <i>‘Medicago</i> , <i>Echium</i> and <i>‘Xanthium</i> spp. together with exotic grasses such as <i>‘Hordeum leporinum</i> and <i>‘Lolium perenne</i> .	

Community 2	Black Box Woodland
Structure: woodland #; woodland - open woodland ##	
Main species: <i>Eucalyptus largiflorens</i> (Black Box)	
Associated species: <i>Chenopodium nitriaceum</i> , <i>Rhagodia spinescens</i> , <i>Atriplex nummularia</i> , <i>Enchylaena tomentosa</i> , <i>Einadia nutans</i> , <i>Muehlenbeckia florulenta</i> .	
Ground-cover species: <i>Chamaeocye drummondii</i> , <i>Atriplex semibaccata</i> , <i>Atriplex leptocarpa</i> , <i>Oxalis perennans</i> , <i>Boerhavia coccinea</i> , <i>Centipedia cunninghamii</i> , <i>Alternanthera denticulata</i> , <i>‘Verbena officinalis</i> , <i>Calotis scapigera</i> .	
Landform: Uppermost floodplain levels, periodically flooded alluvial plains, ephemeral creeks and adjacent flats, dry-lake margins, depressions, drains and channels.	
Soils: Heavy grey and brown clays, self-mulching or compact.	
Occurrence: Black Box forms extensive woodlands on the terrace landform elements adjacent to major creeks and rivers across the mapped area. It is also common in depressions, along major and minor creeks and fringing dry lakes. South of Moulamein and Conargo on the Deniliquin map, <i>Eucalyptus largiflorens</i> often occurs mixed with <i>Eucalyptus microcarpa</i> (Grey Box) and less commonly <i>Eucalyptus melliodora</i> (Yellow Box), gradually being replaced by the former further south on the floodplain. <i>Eucalyptus largiflorens</i> grows on the less frequently flooded areas of the floodplain above the level of the adjacent River Gum forest. It also occurs in ribbon-like along intermittent creeks, fringing lakes, or as a line of very scattered individual trees along drainage lines. <i>Eucalyptus largiflorens</i> often occurs in depressions and other areas of restricted drainage within other vegetation communities such as <i>Callitris glaucophylla</i> , <i>Acacia pendula</i> and mallee woodlands.	
The main understorey species in Black Box woodlands are <i>Chenopodium nitriaceum</i> , <i>Rhagodia spinescens</i> and <i>Enchylaena tomentosa</i> . <i>Chenopodium nitriaceum</i> often extends out beyond the Black Box floodplain to form extensive shrublands, although much has been cleared for irrigated cropping. <i>Atriplex nummularia</i> occasionally forms a tall understorey to <i>Eucalyptus largiflorens</i> . Where the community occurs in wetter, periodically flooded areas, <i>Muehlenbeckia florulenta</i> may be the major understorey component.	

Community 11	Bladder Saltbush
Structure: low shrubland - low open shrubland #; chenopod shrubland - open chenopod shrubland ##	
Main species: <i>Atriplex vesicaria</i> (Bladder Saltbush).	
Associated species: <i>Sclerostegia tenuis</i> , <i>Malacocera tricornis</i> , <i>Disphyma crassifolium</i> subsp. <i>clavellatum</i> , <i>Minuria cunninghamii</i> , <i>Maireana aphylla</i> , <i>Sclerolaena tricuspis</i> , <i>Sclerolaena muricata</i> , <i>Isolaena tomentosa</i> , <i>Eragrostis australasica</i> , <i>Sclerolaena brachyptera</i> , <i>Sclerolaena bicornis</i> var. <i>bicornis</i> , <i>Sclerolaena intricata</i> , <i>Leptorhynchus panetioides</i> , <i>Calceophalus sonderi</i> , <i>Frankenia connata</i> , <i>Maireana decalvans</i> , <i>Disiocarpus biflorus</i> var. <i>biflorus</i> .	
Other common associate species which vary seasonally include: <i>Atriplex lindleyi</i> , <i>Atriplex pseudocampanulata</i> , <i>Rhodanthe corymbiflora</i> , <i>Plantago cunninghamii</i> , <i>Podolepis muelleri</i> , <i>Daucus gluchidiatus</i> , <i>Sida trichopoda</i> , <i>Maireana pentagona</i> , <i>Sclerolaena stelligera</i> , <i>Brachycome lineariloba</i> , <i>Vittadinia cuneata</i> var. <i>cuneata</i> , <i>Chloris truncata</i> , <i>Sporobolus caroli</i> , <i>Agrostis avenacea</i> .	
Landform: Level to depressed alluvial plains.	
Soils: Deep, grey, self-mulching and cracking clays to red clay-loam. Grey clays, clay-loams to sandy loams overlying clay (Knowles & Condon 1951). May also occur in sandy deposits.	
Occurrence: <i>Atriplex vesicaria</i> forms the dominant vegetation community over the mapped area. It is believed to have once covered vast areas of the Hay Plain but that excessive grazing has led to its rapid decline (Beadle 1948, Knowles & Condon 1951). Several dieback events over the past decade have seen a further decline in extent of the species. Post-dieback distribution of <i>Atriplex vesicaria</i> has been mapped. Only small remnant patches exist on the Deniliquin-Bendigo map, these being mainly north of Billabong Creek. Some saltbush occurs in north-western Victoria as discrete areas along the Murray River (Dalton 1988). The largest continuous stands occur north of Hay and west to north-west of Booligal, on the Booligal-Hay map area. A close associate of <i>Atriplex vesicaria</i> is <i>Sclerostegia tenuis</i> , which replaces the former in depressed, saline situations (see Community 12). Large patches of <i>Eragrostis australasica</i> often occur in depressions within both these shrubland communities. <i>Atriplex vesicaria</i> often occurs mixed with <i>Atriplex nummularia</i> on flat to low-lying sites.	

Community 12	Sclerostegia tenuis
Structure: low shrubland #; closed - open chenopod shrubland ##	
Main species: <i>Sclerostegia tenuis</i> (Slender Glasswort), <i>Disphyma crassifolium</i> subsp. <i>clavellatum</i> (Round-leaf Pigface).	
Associated species: <i>Atriplex vesicaria</i> , <i>Eragrostis australasica</i> , <i>Sclerolaena tricuspis</i> , <i>Malacocera tricornis</i> , annual <i>Atriplex</i> spp., <i>Sclerolaena muricata</i> , <i>Sclerolaena brachyptera</i> , <i>Osteocarpum acropterum</i> var. <i>deminuta</i> , <i>Minuria cunninghamii</i> .	
Landform: Saline flats and depressions, depressed alluvial plains.	
Soils: Clay soils in saline situations.	
Occurrence: On depressed saline flats mostly adjacent to irrigated areas. This community is closely allied to <i>Atriplex vesicaria</i> shrubland into which it generally grades, further north on the Booligal-Hay map area. <i>Sclerostegia tenuis</i> becomes the dominant species in particularly well-developed and the community is particularly well-developed on the lower alluvium around Lake Victoria and other dry lakes and saltpans further west (Fox 1991). It is considered a highly salt-tolerant species, being capable of colonising highly saline environments where no other species will grow (Beadle 1948). <i>Sclerostegia tenuis</i> often forms dense mats below Black Box woodland and has decreased significantly in abundance due to grazing and trampling by stock (Cunningham <i>et al.</i> 1981).	

Community 13	Canegrass
Structure: tussock grassland # and ##	
Main species: <i>Eragrostis australasica</i> (Canegrass)	
Associated species: <i>Eleocharis pallens</i> , <i>Juncus flavidus</i> , <i>Juncus aridicola</i> , <i>Muehlenbeckia florulenta</i> , <i>Disphyma crassifolium</i> subsp. <i>clavellatum</i> , <i>Chenopodium nitriaceum</i> .	
Landform: Alluvial plains with depressions and other low-lying areas subject to intermittent flooding or ponding such as swamps, tabledrains and claypans.	
Soils: Slightly saline, compact, heavy grey clays.	
Occurrence: <i>Eragrostis australasica</i> has a very patchy distribution in the north of the Deniliquin-Bendigo map area and within the irrigated country adjacent to the Murray and Edward-Wakool Rivers. It is particularly common in saline depressions within <i>Atriplex vesicaria</i> shrubland further north on the Booligal-Hay map area. It occurs in tabledrains and depressions along the major roads in low-lying and irrigated sites. <i>Eragrostis australasica</i> tolerates regular, but not prolonged flooding, with <i>Muehlenbeckia florulenta</i> (Lignum) occupying the wetter areas (Semple 1990). <i>Chenopodium nitriaceum</i> and <i>Atriplex nummularia</i> may be present around the edges of Canegrass swamps.	

Community 16	Callitris Mixed Woodland
Structure: woodland - low open woodland #; woodland - isolated clumps ##	
Main species: <i>Callitris glaucophylla</i> (White Cypress Pine). <i>Callitris gracilis</i> subsp. <i>murrayensis</i> (Murray Cypress Pine) may replace <i>Callitris glaucophylla</i> on sandhills and ridges adjacent to the Murray River.	
Associated species: <i>Hakea leucopetra</i> , <i>Hakea tephrosperma</i> , <i>Alectryon oleifolius</i> subsp. <i>canescens</i> , occasional <i>Alectryon oleifolius</i> subsp. <i>elongatus</i> , <i>Acacia melvillei</i> , <i>Geijera parviflora</i> , <i>Allocasuarina luehmanni</i> , <i>Maireana pyramidata</i> , <i>Acacia oswaldii</i> , <i>Acacia homalophylla</i> , <i>Pittosporum phylliraoides</i> , <i>Casuarina pauper</i> , <i>Eremophila longifolia</i> , <i>Dodonaea viscosa</i> subsp. <i>angustissima</i> , <i>Senna artemisioides</i> subsp. <i>petiolaris</i> , <i>Acacia brachybotrya</i> , <i>Eucalyptus melliodora</i> .	
Landform: Raised sandy areas such as low linear dunes, sandhills, ridges and footslopes of rocky outcrops. Old stream beds and levee banks of prior streams and source-bordering dunes formed with the redeposition of prior stream material by wind action (Butler <i>et al.</i> 1973). The remnant woodland occupying the major prior streams has been mapped as a separate map unit (see Community 27).	
Soils: Coarse-textured red and brown earths such as sandy-loams and loams.	
Occurrence: Isolated sandhills with <i>Callitris</i> Mixed Woodland occur throughout the mapped area. Source-bordering dunes associated with prior streams and generally running in an east-west direction occur from west of Booroorban on the Booligal-Hay map area, to just north of Moulamein. Continuous, elevated sandridges also occur north of Conargo and Wanganella. Large areas of <i>Callitris glaucophylla</i> occur in Steam Plains, Puckawidgee, Edgar and Thobolin State Forests and on the properties 'Steam Plains' and 'Zara'. Unusual areas of <i>Callitris glaucophylla</i> with an <i>Atriplex nummularia</i> understorey occur on 'Steam Plains' and 'Zara'. Undulating country with remnant <i>Callitris glaucophylla</i> is also seen south-west to south-east of Deniliquin in primarily agricultural land, often associated with remnant Grey Box and Bullock woodland (Community 25). <i>Eucalyptus melliodora</i> (Yellow Box), is associated with <i>Callitris glaucophylla</i> on shallow to deep sandy soils in this area, with <i>Cypress Pine</i> dominating on the sandhills (Moore 1953). <i>Callitris gracilis</i> subsp. <i>murrayensis</i> may replace <i>Callitris glaucophylla</i> on the sandhills and elevated plains adjacent to the Murray River and hybrids of these two species may occur.	
In this community, trees may be widely scattered or may form more or less monospecific groves. <i>Callitris glaucophylla</i> in particular tends to occur in large stands with other species scattered or in groves in between. Grove-forming species include <i>Alectryon oleifolius</i> , <i>Acacia melvillei</i> and <i>Acacia homalophylla</i> . An understorey is rare, but where present may include <i>Rhagodia spinescens</i> and <i>Maireana pyramidata</i> . Much of the original understorey has been grazed out but it is thought that common understorey shrubs may have included species of <i>Dodonaea</i> , <i>Pimelea</i> , <i>Rhagodia</i> , <i>Excarpus</i> and <i>Senna</i> (Noble & Mulham 1980). Generally the ground cover consists of short-lived perennial and annual grasses and herbs, many of them introduced species. The sandy soils are highly prone to wind erosion and degradation by rabbits. Occasionally <i>Callitris glaucophylla</i> may be absent from this community, with the associated trees mentioned above dominating. Some species such as <i>Dodonaea viscosa</i> subsp. <i>angustissima</i> , <i>Eremophila longifolia</i> and <i>Senna</i> species can form a dense, low, monospecific scrub within this community.	

Community 17	Acacia melvillei Woodland
Structure: tall shrubland - low woodland #; shrubland to woodland ##	
Main species: <i>Acacia melvillei</i>	
Associated species: <i>Callitris glaucophylla</i> , <i>Acacia homalophylla</i> , <i>Acacia oswaldii</i> , <i>Alectryon oleifolius</i> subsp. <i>canescens</i> , <i>Casuarina pauper</i> .	
Landform: Level sandplains, undulating plains and low sandy rises.	
Soils: Red-brown clay to sandy loam.	
Occurrence: A small area of <i>Acacia melvillei</i> occurs north of Moulamein. The community is more common further north on the Booligal-Hay map area. <i>Acacia melvillei</i> forms local communities within <i>Callitris</i> Mixed Woodlands (Community 16) of sandy rises and source-bordering dunes, and within the Belah-Rosewood country to the north-west of the mapped area. This community is generally small in extent or forms localised stands within other communities.	

Community 18	Lignum and Chenopodium nitriaceum
Structure: low shrubland - open scrub #; open - closed shrubland ##	
Main species: <i>Muehlenbeckia florulenta</i> (Lignum), <i>Chenopodium nitriaceum</i> (Nitre Goosefoot).	
Associated Species: <i>Eragrostis australasica</i> , <i>Sclerolaena muricata</i> , <i>Juncus flavidus</i> , <i>Juncus radula</i> and other <i>Juncus</i> spp., <i>Senecio cunninghamii</i> var. <i>cunninghamii</i> , <i>Rumex texas</i> , <i>‘Rumex crispus</i> , <i>Atriplex suberecta</i> . Species occurring in wetter areas include <i>Eleocharis acuta</i> , <i>‘Alopecurus geniculatus</i> , <i>Marsilea drummondii</i> and <i>Limosella australis</i> .	
Landform: Intermittently flooded channels, depressions, river-flats and swamps. Flooding is relatively infrequent, but often prolonged.	
Soils: Heavy grey cracking clays.	
Occurrence: This community occurs throughout the mapped region, in remnant patches or bands adjacent to major creeks and rivers, and in other low-lying swampy areas. <i>Chenopodium nitriaceum</i> exceeds Lignum as the dominant species in this community in occasionally inundated areas with less restricted drainage. It is usually seen forming an understorey to <i>Eucalyptus largiflorens</i> and often extends out onto the floodplain beyond the woodland zone to form dense shrublands. It is also common in dry lakes and infrequently flooded depressions. <i>Muehlenbeckia florulenta</i> withstands relatively infrequent but more prolonged flooding and may form a dense, almost impenetrable scrub (Semple 1990). It favours channelled plains and depressions with impeded drainage but nearly always occurs with <i>Chenopodium nitriaceum</i> .	

Community 19	Old Man Saltbush
Structure: low - low open shrubland #; chenopod shrubland - open chenopod shrubland ##	
Main species: <i>Atriplex nummularia</i> (Old Man Saltbush)	
Associated Species: <i>Rhagodia spinescens</i> , <i>Atriplex vesicaria</i> , <i>Enchylaena tomentosa</i> , <i>Einadia nutans</i> , <i>Eucalyptus largiflorens</i> , <i>Sclerostegia tenuis</i> , other <i>Atriplex</i> spp.	
Landform: Level to depressed plains, low-lying areas and depressions.	
Soils: Grey, self-mulching, cracking clays to red duplex soils with grey and brown clays. <i>Atriplex nummularia</i> grows on a wide range of soil types and at all levels of the plain (Cunningham <i>et al.</i> 1981).	
Occurrence: This community occurs throughout the Hay Plain with a patchy distribution. Remnant areas occur between Moulamein and Wanganella, forming an understorey to <i>Eucalyptus largiflorens</i> , with a particularly dense stand seen on 'Bundy'. <i>Atriplex nummularia</i> was once a dominant understorey species to <i>Acacia pendula</i> (Beadle 1948, Moore 1953) but this association no longer exists within the mapped area. The mapped areas of Old Man Saltbush are remnants of once-extensive stands that have been subjected to grazing pressure, rabbit-disturbance and clearing. Many small remnants occur around homesteads and in small holding paddocks that saw little grazing. The larger remnant areas are delineated on the maps but many smaller patches exist, often consisting of only scattered individuals.	

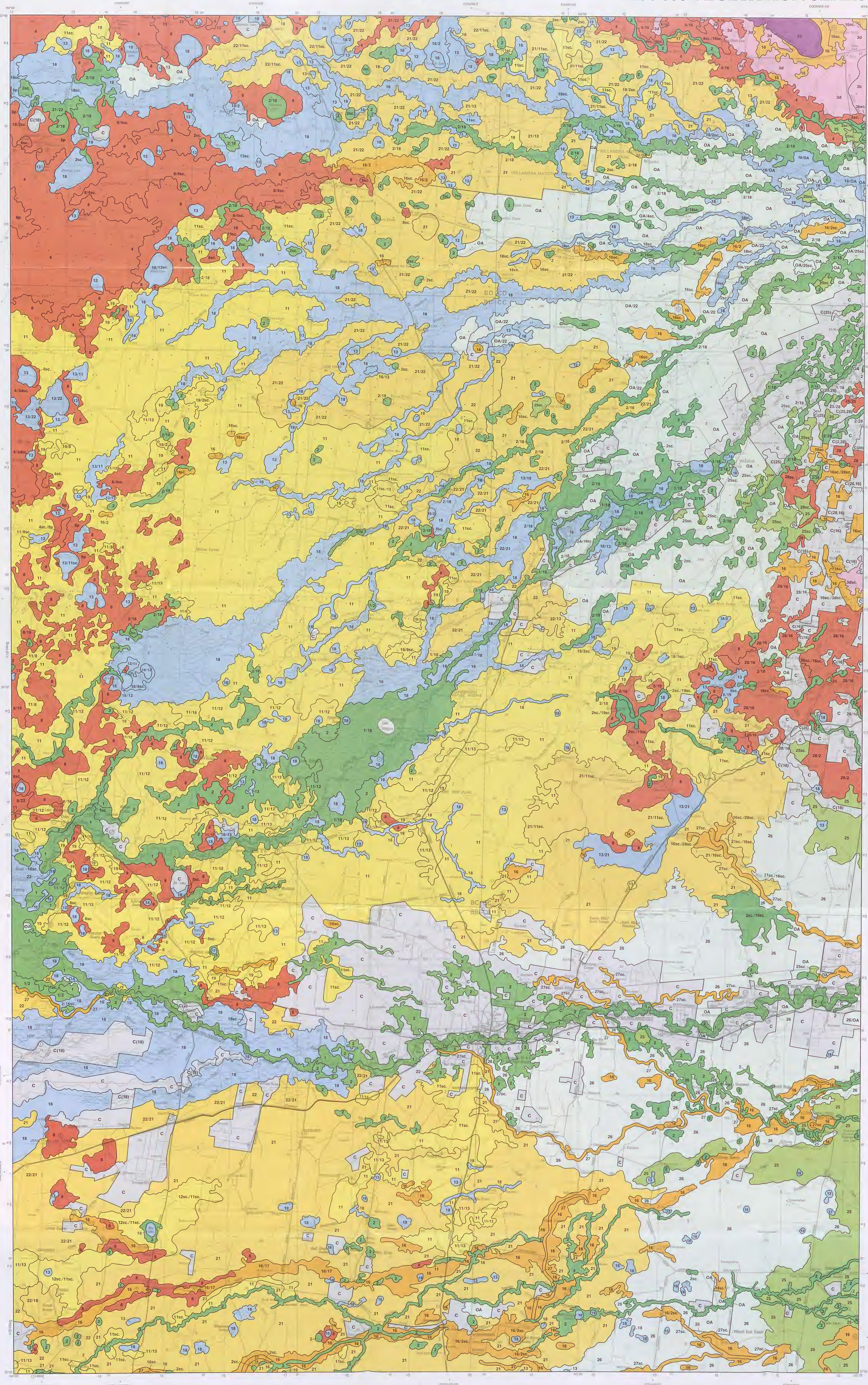
Community 21	Cotton Bush
Structure: low - low open shrubland #; chenopod shrubland - sparse chenopod shrubland ##	
Main species: <i>Maireana aphylla</i> (Cotton Bush)	
Associated Species: <i>Atriplex vesicaria</i> , <i>Sclerolaena muricata</i> , <i>Sclerolaena tricuspis</i> , <i>Nitratia billardieri</i> , <i>Minuria cunninghamii</i> , <i>Isolaena tomentosa</i> , <i>Osteocarpum acropterum</i> var. <i>deminuta</i> , <i>Leptorhynchus panaetioides</i> , <i>Atriplex lindleyi</i> , <i>Atriplex pseudocampanulata</i> , <i>Malacocera tricornis</i> , <i>Danthonia caespitosa</i> , <i>Calceophalus sonderi</i> , <i>Sclerolaena bicornis</i> var. <i>bicornis</i> , <i>Daucus glochidiatus</i> , <i>‘Cotula bipinnata</i> , <i>Rhodanthe corymbiflora</i> , <i>Rhodanthe pygmaea</i> , <i>Plantago cunninghamii</i> , <i>Podolepis muelleri</i> , <i>Calotis scabiosifolia</i> subsp. <i>scabiosifolia</i> , <i>Brachycome lineariloba</i> .	
Landform: Depressed alluvial plains, usually disturbed.	
Soils: Grey to grey-brown clays to clay-loams (Leigh & Mulham 1965).	
Occurrence: This community is widespread over the Hay Plain and has proliferated in many areas once dominated by <i>Atriplex vesicaria</i> . It occurs north of the Edward-Wakool River system within the Deniliquin-Bendigo map area. The largest continuous stands occur further north on the Hay Plain. <i>Maireana aphylla</i> originally occurred with <i>Atriplex vesicaria</i> in slightly depressed areas mainly in the east Darling area and excessive grazing has led to its increase with the elimination of <i>Atriplex vesicaria</i> over large areas (Beadle 1948). Shrublands dominated by <i>Nitratia billardieri</i> , <i>Sclerolaena muricata</i> and <i>Sclerolaena tricuspis</i> indicate greater disturbance. The herbaceous layer within this community consists of short-lived perennial and annual grasses and herbs, many of them introduced, such as <i>‘Avena fatua</i> , <i>‘Hordeum leporinum</i> , <i>‘Lolium perenne</i> , <i>‘Phalaris paradoxa</i> , <i>‘Phalaris minor</i> , <i>‘Bromus madritensis</i> , <i>‘Medicago spp.</i> and <i>‘Erodium</i> spp. <i>Maireana aphylla</i> and <i>Nitratia billardieri</i> tend to occur on slightly depressed areas of the Plain as they are more flood-tolerant than <i>Atriplex vesicaria</i> (Beadle 1948). <i>Maireana aphylla</i> is often associated with medium to heavy scalding and occasional individuals or patches of remnant <i>Atriplex vesicaria</i> may be seen. Shrub cover can vary considerably in this community, ranging from dense monospecific stands to scattered individuals within a matrix comprising annual and short-lived perennial grasses.	

Community 22	Dillon Bush
Structure: low - low open shrubland #; shrubland - sparse shrubland ##	
Main species: <i>Nitratia billardieri</i> (Dillon Bush)	
Associated Species: <i>Maireana aphylla</i> , <i>Sclerolaena muricata</i> , <i>Sclerolaena tricuspis</i> . This community occupies disturbed areas and usually comprises a high proportion of introduced and annual species. Other associated species vary depending on the composition of the original vegetation.	
Landform: Disturbed low-lying alluvial plains, dry lakebeds.	
Soils: Grey to grey-brown clay and loam soils, often saline (Cunningham <i>et al.</i> 1981).	
Occurrence: <i>Nitratia billardieri</i> tends to occur in dense continuous stands in areas of high grazing pressure, particularly adjacent to riverine and box woodlands, and in previously cropped areas. Its distribution has increased markedly with the changed land use in the area since European settlement. Severe overgrazing of the original chenopod species has resulted in the establishment of Dillon Bush in areas once occupied by <i>Atriplex vesicaria</i> and <i>Atriplex nummularia</i> (Noble & Whalley 1978). Dillon Bush commonly occurs in lower densities within other shrubland and woodland communities.	

Community 24	Grey Box Woodland
Structure: low woodland - woodland #; open woodland - woodland ## (<i>Eucalyptus microcarpa</i> occasionally reaches open forest proportions # and #)	
Main species: <i>Eucalyptus microcarpa</i> (Grey Box)	
Associated Species: <i>Allocasuarina luehmanni</i> (Bullock), <i>Eucalyptus melliodora</i> (Yellow Box), <i>Acacia hakeoides</i> , <i>Acacia brachybotrya</i> , <i>Acacia acinacea</i> , <i>Callitris glaucophylla</i> , <i>Senna artemisioides</i> subsp. <i>zygophylla</i> , <i>Senna artemisioides</i> subsp. <i>filifolia</i> and <i>Senna artemisioides</i> nothosubsp. <i>coriacea</i> , <i>Acacia figes</i> .	
Landform: Level to undulating plains, elevated flats and rises adjacent to the Murray and Edward-Wakool river systems.	
Soils: Red-brown earths and heavy clay to loamy alluvial soils (Cunningham <i>et al.</i> 1981). Deeper sandy soils to the south-east of Deniliquin (Moore 1953).	
Occurrence: <i>Eucalyptus microcarpa</i> woodland occurs in the far south of the Hay Plain. It is seen from east to south-west of Deniliquin, extending down to the Murray River and has its northern limit on the Plain within the Edward-Wakool river system, where it forms open forest within River Red Gum communities. <i>Eucalyptus microcarpa</i> gradually replaces <i>Eucalyptus largiflorens</i> south of Deniliquin where it occurs on higher loam soils in association with <i>Allocasuarina luehmanni</i> (Bullock) and <i>Eucalyptus melliodora</i> (Yellow Box). <i>Eucalyptus microcarpa</i> has been extensively cleared and thinned for both grazing and cropping. Around Deniliquin, this species and <i>Allocasuarina luehmanni</i> have been reduced to remnant patches of scattered trees within irrigated agricultural land. Very few areas exist with an intact shrubby understorey, most of these being roadside remnants. Small remnant stands with <i>Acacia</i> and <i>Senna</i> understoreys exist around Mathouri, north-east of Deniliquin, and along Lower Thuk Road east of Barham. Taller <i>Eucalyptus microcarpa</i> forest occurs with <i>Eucalyptus melliodora</i> on the heavy clays within riparian forests. <i>Allocasuarina luehmanni</i> and <i>Callitris glaucophylla</i> are common associates, occurring on higher ground above the level of the <i>Eucalyptus microcarpa</i> . <i>Eucalyptus melliodora</i> is less abundant in this undulating country, observed more often with Grey Box in riparian situations.	

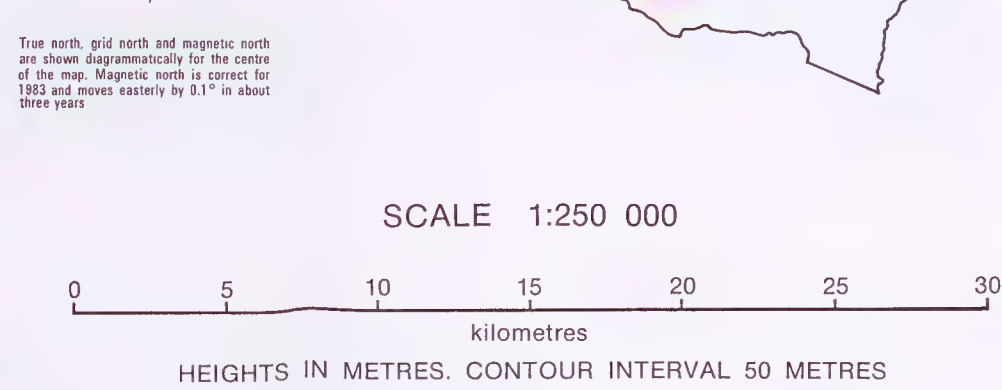
Community 25	Acacia pendula Woodland
Structure: low - low open woodland #; open woodland - woodland ##	
Main species: <i>Acacia pendula</i> (Myall or Boree)	
Associated Species: <i>Rhagodia spinescens</i> , <i>Atriplex nummularia</i> (largely cleared), <i>Danthonia caespitosa</i> , <i>Maireana aphylla</i> , annual <i>Atriplex</i> spp., annual and short-lived perennial grasses, <i>‘Medicago</i> spp., <i>Enchylaena tomentosa</i> , <i>Atriplex semibaccata</i> , <i>Maireana decalvans</i> , <i>Stipa nodosa</i> . <i>Anyema quandang</i> subsp. <i>quandang</i> commonly occurs as a parasite on <i>Acacia pendula</i> .	
Other common associate species which may vary seasonally or with grazing pressure include <i>Alternanthera denticulata</i> , <i>Centipedia cunninghamii</i> , <i>Sida</i> spp., <i>Rhodanthe corymbiflora</i> , <i>Maireana pentagona</i> , <i>Sclerolaena stelligera</i> , <i>Erodium</i> spp., <i>Myriocephalus rhizocephalus</i> subsp. <i>rhizocephalus</i> , <i>‘Cotula bipinnata</i> , <i>Vittadinia cuneata</i> var. <i>cuneata</i> , <i>Lepidium pseudohyssopifolium</i> , <i>Enteropogon acicularis</i> , <i>Ranunculus</i> spp.	
Landform: Level to depressed plains. Adjacent to streams or in depressions in grasslands (Beadle 1981).	
Soils: Grey and brown clays and more rarely on red-brown earths (Beadle 1981, Semple 1990).	
Occurrence: <i>Acacia pendula</i> occurs mainly in the east of the Hay Plain and is seen here at the western limit of its range. It occurs east to north-east of Conargo within the Deniliquin-Bendigo map area, continuing along the eastern edge of the Booligal-Hay map area to Hillston. Isolated groves and scattered trees occur within <i>Danthonia caespitosa</i> grassland (Community 26) and <i>Eucalyptus largiflorens</i> woodland (Community 2). Widespread clearing of <i>Acacia pendula</i> for cropping, fodder and timber has resulted in a patchy remnant distribution. It commonly occurs with a very open structure and a herbaceous understorey, mostly comprising <i>‘Medicago</i> spp. and grasses such as <i>Danthonia caespitosa</i> , <i>Enteropogon acicularis</i> , <i>‘Lolium perenne</i> , <i>‘Hordeum leporinum</i> , <i>‘Vulpia myuros</i> and <i>‘Bromus madritensis</i> . A shrubby understorey is rare or lacking. The original <i>Atriplex nummularia</i> understorey has been largely cleared. Moore (1953) noted remnants as existing in the Jerilderie area. <i>Atriplex vesicaria</i> and <i>Maireana aphylla</i> are also listed as original understorey components with the latter persisting over the two species (Beadle 1981). There are few tree associates but where present may include <i>Acacia salicina</i> and <i>Acacia oswaldii</i> (Beadle 1981).	

Community 26	White-top Grassland
Structure: tussock grassland - open tussock grassland #; grassland - open grassland ##	
Main species: <i>Danthonia caespitosa</i> (White-top or Ringed Wallaby Grass) predominantly, but there is usually a <i>Danthonia eriantha</i> component of about 10 per cent.	
Associated Species: <i>Chloris truncata</i> (Windmill Grass), <i>Enteropogon acicularis</i> , <i>Sporobolus caroli</i> , <i>Bromus arenarius</i> , <i>Stipa nodosa</i> , <i>‘Hordeum leporinum</i> , <i>‘Lolium perenne</i> , <i>‘Lolium rigidum</i> , <i>‘Avena fatua</i> , <i>‘Bromus madritensis</i> , <i>‘Vulpia myuros</i> , <i>‘Medicago</i> spp., <i>‘Erodium</i> spp., <i>Rhodanthe corymbiflora</i> , <i>Sida trichopoda</i> , <i>Sida corrugata</i> , <i>Maireana aphylla</i> (occasionally).	
Landform: Level alluvial plains.	
Soils: Grey to brown clays or clay-loams, usually with a compacted surface (Beadle 1948).	
Occurrence: This grassland is composed of short-lived perennial and annual grasses and occurs in the east to south-east of the Hay Plain, extending from north-east of Deniliquin to south of Gunbar on the Booligal-Hay map area. The most homogeneous areas are found south-east to north-east of Hay. <i>Danthonia caespitosa</i> may dominate the ground layer in <i>Eucalyptus largiflores</i> , <i>Acacia pendula</i> and other woodland communities. Short-lived perennial and annual grasses dominate the pasture in more disturbed communities with a seasonal composition. Common species include <i>‘Hordeum leporinum</i> , <i>‘Lolium perenne</i> , <i>‘Avena fatua</i> and <i>‘Bromus madritensis</i> . At various times of the year <i>‘Medicago</i> spp., <i>‘Erodium</i> spp. and other herbs (commonly Asteraceae) are a significant component of the ground layer.	



MAP UNIT DESCRIPTIONS			
No.	Plant Community	Main Species	Habitat
1	Rivine Forest	<i>Eucalyptus camaldulensis</i>	open forest
2	Black Box Woodland	<i>Eucalyptus largiflorens</i>	woodland - open woodland
25	<i>Acacia pendula</i> Woodland	<i>Acacia pendula</i>	woodland - open woodland
16	<i>Callitris</i> Mixed Woodland	<i>Callitris glaucochyta</i> , <i>Callitris gracilis</i> subsp. <i>murrayensis</i> (south of Deniliquin)	woodland - isolated clumps
17	<i>Acacia melvillei</i>	<i>Acacia melvillei</i>	woodland - shrubland
27	Prior Stream Remnant Woodland	<i>Callitris glaucochyta</i> , <i>Hakea leucophaea</i> , <i>Hakea leptophylla</i>	open woodland - isolated trees
4	Belah-Rosewood	<i>Casuarina paupers</i> , <i>Alectryon oleifolius</i> subsp. <i>canescens</i>	open woodland - isolated clumps
28	<i>Casuarina paupers</i> / <i>Casuarina cristata</i> Intergrading Population	<i>Casuarina paupers</i> , <i>Casuarina cristata</i>	woodland - open woodland
6	Black Bluebush	<i>Maireana pyramidalis</i>	open - sparse chenopod shrubland
8p	Black and Pearl Bluebushes	<i>Maireana pyramidalis</i> , <i>Maireana seiffertii</i>	open - sparse chenopod shrubland
3b	Dune-Crest Mallee	<i>Eucalyptus socialis</i> , <i>Eucalyptus dumosa</i> , <i>Triodia scarsoni</i>	mallee shrubland - open mallee shrubland
3d	Sandplain Mallee	<i>Eucalyptus socialis</i> , <i>Eucalyptus dumosa</i>	mallee shrubland - open mallee shrubland
29	Rocky Outcrop Woodland Complex	<i>Callitris glaucochyta</i> , <i>Eucalyptus intertexta</i> , <i>Eucalyptus vicina</i>	woodland - open woodland
19	Old Man Saltbush	<i>Atriplex nummularia</i>	chenopod shrubland - open chenopod shrubland
11	Bladder Saltbush	<i>Atriplex vesicaria</i>	chenopod shrubland - open chenopod shrubland
12	<i>Sclerostegia tenuis</i>	<i>Sclerostegia tenuis</i> , <i>Disphyma crassifolium</i> subsp. <i>clavellatum</i>	closed - open chenopod shrubland
21	Cottonbush	<i>Maireana aphylla</i>	chenopod shrubland - sparse chenopod shrubland
22	Dillon Bush	<i>Nitraria billardierei</i>	shrubland - sparse shrubland
26	White-top Grassland	<i>Danthionia caespitosa</i>	grassland - open grassland
OA	Open Areas	various grasses, herbs and forbs	grassland - forbland
13	Canegrass	<i>Eragrostis australasica</i>	tussock grassland
18	Lignum and <i>Chenopodium nitratum</i>	<i>Muehlenbeckia florulenta</i> , <i>Chenopodium nitratum</i>	closed - open shrubland
23	Great Cumbung Swamp	<i>Phragmites australis</i> , <i>Senecio cunninghamii</i> , <i>Typha orientalis</i> , <i>Typha domingensis</i>	closed - open grassland/ rushland/forbland
C	Cleared and/or Cropped		
sc.	scattered		

Present vegetation as at January 1993. Clearing marked from LANDSAT TM imagery dated 01-01-1993 to 10-01-1993.



KEY TO ADJOINING 1:250 000 MAPS

MANARA SI 54-4	IVANHOE SI 55-1	NYMAGEE SI 55-2
POONCARIE SI 54-8	BOOLIGAL SI 55-5	CARGELLIGO SI 55-6
BALRANALD SI 54-12	HAY SI 55-9	NARRANDERA SI 55-10
SWAN HILL SI 54-16	DENILIQUIN SI 55-13	JERILDERRIE SI 55-14

Topographic base from Booligal SI 55-5 and Hay SI 55-9 1:250 000 map sheets are Crown Copyright and have been reproduced with the permission of the General Manager, Australian Survey and Land Information Group, Department of Administrative Services, Canberra, ACT.

This project was jointly funded by the Natural Resources Management Strategy of the Murray-Darling Basin Commission, and the Royal Botanic Gardens, Sydney.

PLANT COMMUNITIES OF THE BOOLIGAL-HAY 1:250 000 MAP SHEET

Community 1	Riverine Forest
Structure: open forest # and ##	
Main species: <i>Eucalyptus camaldulensis</i> (River Red Gum)	
Associated species: <i>Acacia stenophylla</i> , <i>Muehlenbeckia florulenta</i> , <i>Eucalyptus largiflorens</i> , <i>Chenopodium nitraticeum</i> , <i>Acacia salicina</i> , <i>Lyxium forficatum</i> .	
Ground-cover species: <i>Pratia concolor</i> , <i>Glinus lotoideis</i> , <i>Oxalis perennans</i> , <i>Centipeda cunninghamii</i> , <i>Paspalum jubiflorum</i> , <i>Alternanthera denticulata</i> , <i>Chamaecybe drummondii</i> , <i>Colutea australis</i> , <i>Marsilea drummondii</i> , <i>Carex appressa</i> , <i>Poa fordeana</i> , <i>Agrostis avenacea</i> , <i>Colutea bipinnata</i> , <i>Solanum nigrum</i> , <i>Sonchus oleraceus</i> .	
Landform: River and creek levees and adjacent flats, channelled plains and other areas subject to frequent or periodic flooding.	
Soils: Heavy grey, brown and red clays.	
Occurrence: This community occurs along the major river systems of the Murrumbidgee and Lachlan Rivers and other rivers and creeks throughout the mapped area. In the drier north, creeks and rivers will tend to be fringed with <i>Eucalyptus largiflorens</i> (Black Box), although <i>Eucalyptus camaldulensis</i> will occur with Black Box wherever periodic flooding occurs. A more open <i>Eucalyptus camaldulensis</i> woodland is found on the channelled floodplain of the Lachlan River south-west of Booligal. A shrub layer is normally absent in this community, with leaf and branch litter dominating the ground layer. Shrubs, if present, may include <i>Muehlenbeckia florulenta</i> (Lignum), <i>Chenopodium nitraticeum</i> and <i>Lyxium forficatum</i> . <i>Muehlenbeckia florulenta</i> and <i>Eragrostis australasica</i> may occur in intermittently flooded channels within the floodplain while areas of semi-permanent still water support rushlands of <i>Typha</i> spp., <i>Phragmites australis</i> , <i>Juncus</i> spp. and <i>Eleocharis</i> spp. The herbaceous layer varies seasonally and, as well as the species listed, may include <i>Rumex</i> , <i>Medicago</i> , <i>Ecium</i> and <i>Xanthium</i> spp. together with exotic grasses such as <i>Hordeum leporinum</i> and <i>Lolium perenne</i> .	

Community 2	Black Box Woodland
Structure: woodland #; woodland - open woodland ##	
Main species: <i>Eucalyptus largiflorens</i> (Black Box)	
Associated species: <i>Chenopodium nitraticeum</i> , <i>Rhagodia spinescens</i> , <i>Atriplex nummularia</i> , <i>Enchylaena tomentosa</i> , <i>Einadia nutans</i> , <i>Muehlenbeckia florulenta</i> .	
Ground-cover species: <i>Chamaecybe drummondii</i> , <i>Atriplex semibaccata</i> , <i>Atriplex leptocarpa</i> , <i>Oxalis perennans</i> , <i>Boerhavia coccinea</i> , <i>Centipeda cunninghamii</i> , <i>Alternanthera denticulata</i> , <i>Wortia ornamentalis</i> , <i>Calceis scapiger</i> .	
Landforms: Uppermost floodplain levels, periodically flooded alluvial plains, ephemeral creeks and adjacent flats, dry-lake margins, depressions, drains and channels.	
Soils: Heavy grey and brown clays, self-mulching or compact.	
Occurrence: Black Box forms extensive woodlands on the terrace landform elements adjacent to major creeks and rivers across the mapped area. It is also common in depressions, along major and minor creeks (especially north of the Murrumbidgee River) and fringing dry lakes. <i>Eucalyptus largiflorens</i> grows on the less frequently flooded areas of the floodplain above the level of the adjacent River Red Gum forest. It also occurs in ribbon stands along intermittent creeks, fringing lakes, or as a line of very scattered individual trees along drainage lines. <i>Eucalyptus largiflorens</i> often occurs in depressions and other areas of restricted drainage within other vegetation communities such as <i>Callitris glaucophylla</i> , <i>Acacia pendula</i> and mallee woodlands.	
The main understory species in Black Box woodlands are <i>Chenopodium nitraticeum</i> , <i>Rhagodia spinescens</i> and <i>Enchylaena tomentosa</i> . <i>Chenopodium nitraticeum</i> often extends out beyond the Black Box floodplain to form extensive shrublands, although much has been cleared for irrigated cropping. <i>Atriplex nummularia</i> occasionally forms a tall understory to <i>Eucalyptus largiflorens</i> . Where the community occurs in wetter, periodically flooded areas, <i>Muehlenbeckia florulenta</i> may be the major understory component.	

Community 3	Mallee
Structure: tall shrubland to low woodland #; mallee shrubland to open mallee shrubland (rarely open mallee woodland) ##. 'Whipstick' mallee is a low, stunted multi-stemmed growth form, indicating a sandy soil of low fertility and commonly occurring on the dune crests. 'Bull' mallee, a taller form with fewer stems, indicates a more fertile and less sandy soil and occurs in the heavier soils of the swales (Beadle 1948, Noble et al. 1980).	
Main species: <i>Eucalyptus socialis</i> (Pointed Mallee), <i>Eucalyptus dumosa</i> (Congo Mallee).	
Associated species: <i>Eucalyptus gracilis</i> , <i>Eucalyptus leptophylla</i> , <i>Senna artemisioides</i> subsp. <i>filifolia</i> , <i>Senna artemisioides</i> subsp. <i>petiolaris</i> , <i>Dodonaea viscosa</i> subsp. <i>angustissima</i> , <i>Acacia colletioides</i> , <i>Eucalyptus intertexta</i> , <i>Eucalyptus populnea</i> subsp. <i>bimbi</i> , <i>Callitris glaucophylla</i> and <i>Acacia melvillei</i> , as well as <i>Casuarina pauper</i> with <i>Alecryon oleifolius</i> , form local communities within the mallee.	
The following species are associated with particular geomorphological variation within the mallee:	
3b Dune-Crest Mallee: <i>Tridolia scariosa</i> , <i>Lomandra effusa</i> , <i>Olearia pimeleoides</i> , <i>Eremophila glabra</i> , <i>Eremophila sturtii</i> , <i>Acacia wilhelmiana</i> .	
3d Sandplain Mallee: <i>Maireana pyramidata</i> , <i>Enchylaena tomentosa</i> , <i>Dissoctopus paradoxus</i> , <i>Rhagodia spinescens</i> . Note: These shrubs occur more commonly in the Sandplain Mallee in the west of the mapped area. The Sandplain Mallee of the north-east supports a different shrub layer of mostly <i>Senna</i> , <i>Dodonaea</i> and <i>Acacia</i> species, with a high bark litter ground component.	
Landform: Level to undulating sandplains and irregular dunefields with low, discontinuous, linear dunes.	
Soils: Calcareous red earths with sandy loam to clay loam surface and red desert loams derived from aeolian materials (Scriven 1988a, Eldridge 1999).	
Occurrence: Two distinct areas of mallee occur on the Booligal map area. In the north-eastern sector, the mallee is characterised by sandplains and low irregular dunes with some dune-crest mallee, and interspersed with higher sandhills supporting <i>Callitris glaucophylla</i> and undulating areas of Belah-Rosewood. South of Hillston the mallee is of the 'bull'-type, with large, few-stemmed trees. Due to extensive cropping in this area the mallee is very much of a remnant nature with a cleared understory. North of Hillston and extending north and north-west to Roto and Trida railway sidings, extensive stands of whipstick mallee occur with a well-developed shrubby understory. The second area of mallee occurs in the aeolian-alluvial geomorphological transition zone in the west. Aeolian sandplains carrying mallee with <i>Maireana pyramidata</i> (Belt Bluebush) understory occur on the south-western edge of the Booligal map. This is primarily within Belah-Rosewood country (see Community 4) along the Clare-Oxley and Hatfield roads. Extensive dunefields supporting mallee on the dune crests and Belah-Rosewood in the swales occur further west.	

Community 4	Belah-Rosewood
Structure: low woodland - low open woodland #; open woodland - isolated clumps ##	
Main species: <i>Casuarina pauper</i> (Belah), <i>Alecryon oleifolius</i> subsp. <i>canescens</i> (Rosewood), <i>Alecryon oleifolius</i> subsp. <i>elongatus</i> occurs less commonly; this subspecies has a more eastern distribution and grows on heavier soils (Harden 1999-02).	
Associated species: <i>Maireana pyramidata</i> , <i>Geljiera parviflora</i> , <i>Exocarpos aphyllus</i> , <i>Rhagodia spinescens</i> , <i>Acacia victoriae</i> , <i>Acacia melvillei</i> , <i>Dissoctopus paradoxus</i> , <i>Maireana sedifolia</i> , <i>Myoporum platycarpum</i> , <i>Maireana humilis</i> .	
Landform: Level to undulating sandplains and aeolian dunes.	
Soils: Calcareous earths, mainly of red to red-brown loam to loamy sand. Solonised brown soils to sandy red earths (Cunningham et al. 1981). Reddish-brown sands and texture-contrast (duplex) soils (Scriven 1988b). Red-brown soils with light-textured topsoil and calcareous subsoil (Wilson & Johnson 1989).	
Occurrence: Belah-Rosewood occurs across the north and in the west to north-west of the Booligal map area. The densest continuous areas of Belah-Rosewood clumps occur along the Ivanhoe-Bairnland Road in the north-west of the map and east of Mossiegl along the Alma Lake and East Clare roads. Dense <i>Casuarina pauper</i> was also observed in a distinct tier on the lower slopes of Warranary Hill, a rocky outcrop in the far north-east of the map (Community 29). <i>Casuarina pauper</i> and <i>Alecryon oleifolius</i> are distributed in monospecific groves within this community with little mixing of the two species. Groves or clumps of trees may be many metres apart. An open <i>Maireana pyramidata</i> understory is common, with the ground layer of the calcareous soils at higher elevations. <i>Callitris glaucophylla</i> , <i>Pittosporum phyllarioides</i> , <i>Hakea leucostachya</i> and <i>Hakea tetraepora</i> occur sandier areas of higher elevation within this community. <i>Acacia melvillei</i> groves are also common on sandy-loam areas while scattered trees of <i>Flindersia maculosa</i> may also occur.	

Community 8	Black Bluebush
Structure: low shrubland - low open shrubland #; chenopod shrubland - sparse chenopod shrubland ##	
Main species: <i>Maireana pyramidata</i> (Black Bluebush) Sp. <i>Maireana pyramidata</i> , <i>Maireana sedifolia</i> (Pearl Bluebush)	
Associated species: <i>Rhagodia spinescens</i> , <i>Enchylaena tomentosa</i> , <i>Atriplex lindleyi</i> , <i>Dissoctopus paradoxus</i> , <i>Maireana georgii</i> , <i>Sida nitida</i> , <i>Sida scabra</i> subsp. <i>falcaea</i> , <i>Sida scabra</i> subsp. <i>scabra</i> , <i>Eragrostis dielsii</i> , other <i>Atriplex</i> spp. and <i>Scleroetena</i> spp.	
Landform: Low sandy rises, undulating plains, lunette remnants, prior stream levees.	
Soils: Calcareous sands and loams, red-brown duplex soils with sandy topsoils and clayey subsoils. The distribution of <i>Maireana pyramidata</i> and <i>Maireana sedifolia</i> appears to be determined by soil calcareousness. Black Bluebush dominates where limestone lies at a depth of 1.2 m or more below the soil surface while soils containing shallower limestone will also support Pearl Bluebush (Beadle 1948).	
Occurrence: This shrubland community is common in the north to north-west of the mapped area, where the country becomes undulating and duplex soils predominate. Smaller rises with <i>Maireana pyramidata</i> occur throughout, particularly on scalded prior stream levees and flats. Large and often dense areas of <i>Maireana pyramidata</i> with <i>Maireana sedifolia</i> occur north of Oxley, west of Alma Lake and south of Ivanhoe, although <i>Maireana sedifolia</i> does not occur as the dominant species in these localities. Dense continuous stands, often with <i>Maireana sedifolia</i> , occur on raised areas with deeper sandy or sandy-loam soils. This community often grades into <i>Atriplex vesicaria</i> or <i>Atriplex nummularia</i> on flats and lower areas. Both bluebush species also occur as an understory to Belah-Rosewood, commonly extending into adjacent areas of this woodland and occasionally into mallee. <i>Maireana pyramidata</i> is a common species on the veneer of aeolian material that indicates the transition from riverine or lacustrine landforms.	

Community 11	Bladder Saltbush
Structure: low shrubland - low open shrubland #; chenopod shrubland - open chenopod shrubland ##	
Main species: <i>Atriplex vesicaria</i> (Bladder Saltbush).	
Associated species: <i>Sclerostegia tenuis</i> , <i>Malacocera tricornis</i> , <i>Diaphyma crassifolium</i> subsp. <i>clavellatum</i> , <i>Minuria cunninghamii</i> , <i>Maireana aphylla</i> , <i>Sclerostegia tricuspid</i> , <i>Sclerostegia muricata</i> , <i>Isolaena tomentosa</i> , <i>Eragrostis australasica</i> , <i>Sclerostegia brachyptera</i> , <i>Sclerostegia bicornis</i> var. <i>bicornis</i> , <i>Sclerostegia intricata</i> , <i>Lophorhynchus panatoides</i> , <i>Calceophalus sonderi</i> , <i>Frankenia connata</i> , <i>Maireana decalvans</i> , <i>Dissoctopus biflorus</i> var. <i>biflorus</i> .	
Other common associate species which vary seasonally include: <i>Atriplex lindleyi</i> , <i>Atriplex pseudocamparipata</i> , <i>Rhodanthe corymbiflora</i> , <i>Plantago cunninghamii</i> , <i>Podolpis muelleri</i> , <i>Daucus gluchidiatus</i> , <i>Sida trichopoda</i> , <i>Maireana pentagona</i> , <i>Sclerostegia stolligera</i> , <i>Brachycome lineariloba</i> , <i>Vittadinia cuneata</i> var. <i>cuneata</i> , <i>Oxalis truncata</i> , <i>Sporobolus caroli</i> , <i>Agrostis avenacea</i> .	
Landform: Level to depressed alluvial plains.	
Soils: Deep, grey, self-mulching and cracking clays to red clay-loam. Grey clays, clay-loams to sandy loams overlying clay (Knowles & Condon 1951). May also occur in sandy deposits.	
Occurrence: <i>Atriplex vesicaria</i> forms the dominant vegetation community over the mapped area. It is believed to have once covered vast areas of the Hay Plain but that excessive grazing has led to its rapid decline (Beadle 1948, Knowles & Condon 1951). Several dieback events over the past decade have seen a further decline in extent of the species. Post-dieback distribution of <i>Atriplex vesicaria</i> has been mapped. The largest continuous stands occur north of Hay and west to north-west of Booligal, particularly around One Tree, Oxley, 'Freshwater' and 'Cuplataro'. A close associate of <i>Atriplex vesicaria</i> is <i>Sclerostegia tenuis</i> , which replaces the former in depressed, saline situations (see Community 12). Large patches of <i>Eragrostis australasica</i> often occur in depressions within both these shrubland communities. Bluebush rises often grade into Bladder Saltbush shrubland at lower levels. <i>Atriplex vesicaria</i> often occurs mixed with <i>Atriplex nummularia</i> on flat to low-lying sites.	

Community 12	Sclerostegia tenuis
Structure: low shrubland #; closed - open chenopod shrubland ##	
Main species: <i>Sclerostegia tenuis</i> (Slender Glasswort), <i>Diaphyma crassifolium</i> subsp. <i>clavellatum</i> (Round-leaf Pigface).	
Associated species: <i>Atriplex vesicaria</i> , <i>Eragrostis australasica</i> , <i>Sclerostegia tricuspid</i> , <i>Malacocera tricornis</i> , annual <i>Atriplex</i> spp., <i>Sclerostegia muricata</i> , <i>Sclerostegia brachyptera</i> , <i>Osteocarpum aroeratum</i> var. <i>deminuta</i> , <i>Minuria cunninghamii</i> .	
Landform: Saline flats and depressions, depressed alluvial plains.	
Soils: Clay soils in saline situations.	
Occurrence: On depressed saline flats mostly in the west of the mapped area. Large patches occur with <i>Atriplex vesicaria</i> around Oxley and 'Corrong' on the Hay map and west of Dry Lake. This community is closely allied to <i>Atriplex vesicaria</i> shrubland into which it generally grades. <i>Sclerostegia tenuis</i> becomes the dominant species in more saline situations and the community is particularly well-developed on the lower alluvium around Lake Victoria and other dry lakes and saltpans further west (Fox 1991). It is considered a highly salt-tolerant species, being capable of colonising highly saline environments where no other species will grow (Beadle 1948). <i>Sclerostegia tenuis</i> often forms dense mats below Black Box woodland and has decreased significantly in abundance due to grazing and trampling by stock (Cunningham et al. 1981).	

Community 13	Canegrass
Structure: tussock grassland # and ##	
Main species: <i>Eragrostis australasica</i> (Canegrass)	
Associated species: <i>Eleocharis pallens</i> , <i>Juncus flavidus</i> , <i>Juncus aridicola</i> , <i>Muehlenbeckia florulenta</i> , <i>Diaphyma crassifolium</i> subsp. <i>clavellatum</i> , <i>Chenopodium nitraticeum</i> .	
Landform: Alluvial plains with depressions and other low-lying areas subject to intermittent flooding or ponding such as swamps, tablelands and claypans.	
Soils: Slightly saline, compact, heavy grey clays.	
Occurrence: <i>Eragrostis australasica</i> occurs throughout the mapped area. It is particularly common in saline depressions within <i>Atriplex vesicaria</i> shrubland north of Hay, on the Lachlan River floodplain between Oxley and Booligal and in tablelands and depressions along the major roads in low-lying and irrigated areas. <i>Eragrostis australasica</i> tolerates regular, but not prolonged flooding, with <i>Muehlenbeckia florulenta</i> (Lignum) occupying the wetter areas (Semple 1990). <i>Chenopodium nitraticeum</i> and <i>Atriplex nummularia</i> may be present around the edges of Canegrass swamps. Areas of <i>Eragrostis australasica</i> tend to be small and patchy rather than large and continuous. The species commonly occurs in depressions within the general matrix of <i>Atriplex vesicaria</i> or <i>Maireana aphylla</i> and these areas have been mapped as composite units (11/13 and 21/13).	

Community 16	Callitris Mixed Woodland
Structure: woodland - low open woodland #; woodland - isolated clumps ##	
Main species: <i>Callitris glaucophylla</i> (White Cypress Pine).	
Associated species: <i>Hakea leucostachya</i> , <i>Hakea tephrosperma</i> , <i>Alecryon oleifolius</i> subsp. <i>canescens</i> , occasional <i>Alecryon oleifolius</i> subsp. <i>elongatus</i> , <i>Acacia melvillei</i> , <i>Geljiera parviflora</i> , <i>Alfalcasaria lehmannii</i> , <i>Acacia psowaldi</i> , <i>Acacia homophylla</i> , <i>Pittosporum phyllarioides</i> , <i>Casuarina pauper</i> , <i>Eremophila longifolia</i> , <i>Dodonaea viscosa</i> subsp. <i>angustissima</i> , <i>Senna artemisioides</i> subsp. <i>petiolaris</i> , <i>Maireana pyramidata</i> , <i>Acacia victoriae</i> , <i>Eucalyptus populnea</i> subsp. <i>bimbi</i> and <i>Eucalyptus intertexta</i> occur in the north-east of the mapped area with <i>Callitris glaucophylla</i> .	
Landform: Raised sandy areas such as low linear dunes, sandhills, ridges and footslopes of rocky outcrops. Old stream beds and levee banks of prior streams and source-bordering dunes formed with the redeposition of prior stream material by wind action (Butler et al. 1973). The remnant woodland occupying the major prior streams has been mapped as a separate map unit (see Community 27).	
Soils: Coarse-textured red and brown earths such as sandy-loams and loams.	
Occurrence: Isolated sandhills with <i>Callitris Mixed Woodland</i> occur throughout the mapped area. Source-bordering dunes associated with prior streams and generally running in an east-west direction occur in the south, notably from west of Booroorban, through the Tcheley Woolsheds area to just north of Moudah. Large areas of <i>Callitris glaucophylla</i> occur in Booroorban State Forest and on the properties 'Oolimbayan' and 'Gum Creek'. Dense stands of <i>Callitris glaucophylla</i> also occur within the mallee, Belah-Rosewood and <i>Casuarina pauper/Casuarina cristata</i> intergrading population, along the eastern edge of the mapped area. Rocky outcrops seen further north support a different Cypress Pine community, described under map unit 23.	

In this community, trees may be widely scattered or may form more or less monospecific groves. *Callitris glaucophylla* in particular tends to occur in large stands with other species scattered or in groves in between. Grove-forming species include *Alecryon oleifolius*, *Acacia melvillei* and *Acacia homophylla*. An understorey is rare, but where present may include *Maireana pyramidata* and *Rhagodia spinescens*. Much of the original understory has been grazed out but it is thought that common understory species may have included species such as *Dodonaea*, *Pimelea*, *Rhagodia*, *Exocarpos* and *Senna* (Noble & Mulham 1980). Generally the ground cover consists of short-lived perennial and annual grasses and herbs, many of them introduced species. The sandy soils are highly prone to wind erosion and degradation by rabbits. Occasionally *Callitris glaucophylla* may be absent from this community, with the associated trees mentioned above dominating. *Acacia victoriae* is occasionally seen as a dominant on slight rises north of Booligal. Some species such as *Dodonaea viscosa* subsp. *angustissima*, *Eremophila longifolia* and *Senna* species can form a dense, low, monospecific scrub within this community. Large areas of these woody shrubs occur along the Booroorban-Tcheley road, in Belah-Rosewood country south-west and south-east of Ivanhoe, and in the mallee between Corbelle and Roto.

Community 17	Acacia melvillei Woodland
Structure: tall shrubland - low woodland #; shrubland to woodland ##	
Main species: <i>Acacia melvillei</i>	
Associated species: <i>Callitris glaucophylla</i> , <i>Acacia homophylla</i> , <i>Acacia oswaldi</i> , <i>Alecryon oleifolius</i> subsp. <i>canescens</i> , <i>Casuarina pauper</i> .	
Landform: Level sandplains, undulating plains and low sandy rises.	
Soils: Red-brown clay to sandy loam.	
Occurrence: Dense <i>Acacia melvillei</i> areas occur between Trida and Wee Elwah in the far north of the Booligal map area, north of Gunbar along McKinley Road, and north of Moulmain in the south-west. Significant stands were also observed around Ivanhoe, to the north of the mapped area. <i>Acacia melvillei</i> forms local communities within Callitris Mixed Woodlands (Community 16) of sandy rises and source-bordering dunes throughout the mapped area, and within the Belah-Rosewood country of the north-west. This community is generally small in extent or forms localised stands within other communities. Several large homogeneous areas have been mapped.	

Community 18	Lignum and Chenopodium nitraticeum
Structure: low shrubland - open scrub #; open - closed shrubland ##	
Main species: <i>Muehlenbeckia florulenta</i> (Lignum), <i>Chenopodium nitraticeum</i> (Nitre Goosefoot).	
Associated Species: <i>Eragrostis australasica</i> , <i>Sclerostegia muricata</i> , <i>Juncus flavidus</i> , <i>Juncus radula</i> and other <i>Juncus</i> spp., <i>Senecio cunninghamii</i> var. <i>cunninghamii</i> , <i>Rumex texa</i> , <i>Rumex crispus</i> , <i>Atriplex subcordata</i> . Species occurring in wetter areas include <i>Eleocharis acuta</i> , <i>Alopecurus geniculatus</i> , <i>Marsilea drummondii</i> and <i>Limnola australis</i> .	
Landform: Intermittently flooded channels, depressions, river-flats and swamps. Flooding is relatively infrequent, but often prolonged.	
Soils: Heavy grey cracking clays.	
Occurrence: This community occurs throughout the mapped region, in bands adjacent to major creeks and rivers and in low-lying swampy areas, particularly north of Booligal and adjacent to the Murrumbidgee and Lachlan Rivers. <i>Chenopodium nitraticeum</i> exceeds Lignum as the dominant species in this community in occasionally inundated areas with less restricted drainage. It is usually seen forming an understory to <i>Eucalyptus largiflorens</i> and often extends out onto the floodplain beyond the woodland zone to form dense shrublands. It is also common in dry lakes and infrequently flooded depressions. <i>Muehlenbeckia florulenta</i> withstands relatively infrequent but more prolonged flooding and may form a dense, almost impenetrable scrub (Semple 1990). It favours channelled plains and depressions with impeded drainage but nearly always occurs with <i>Chenopodium nitraticeum</i> .	

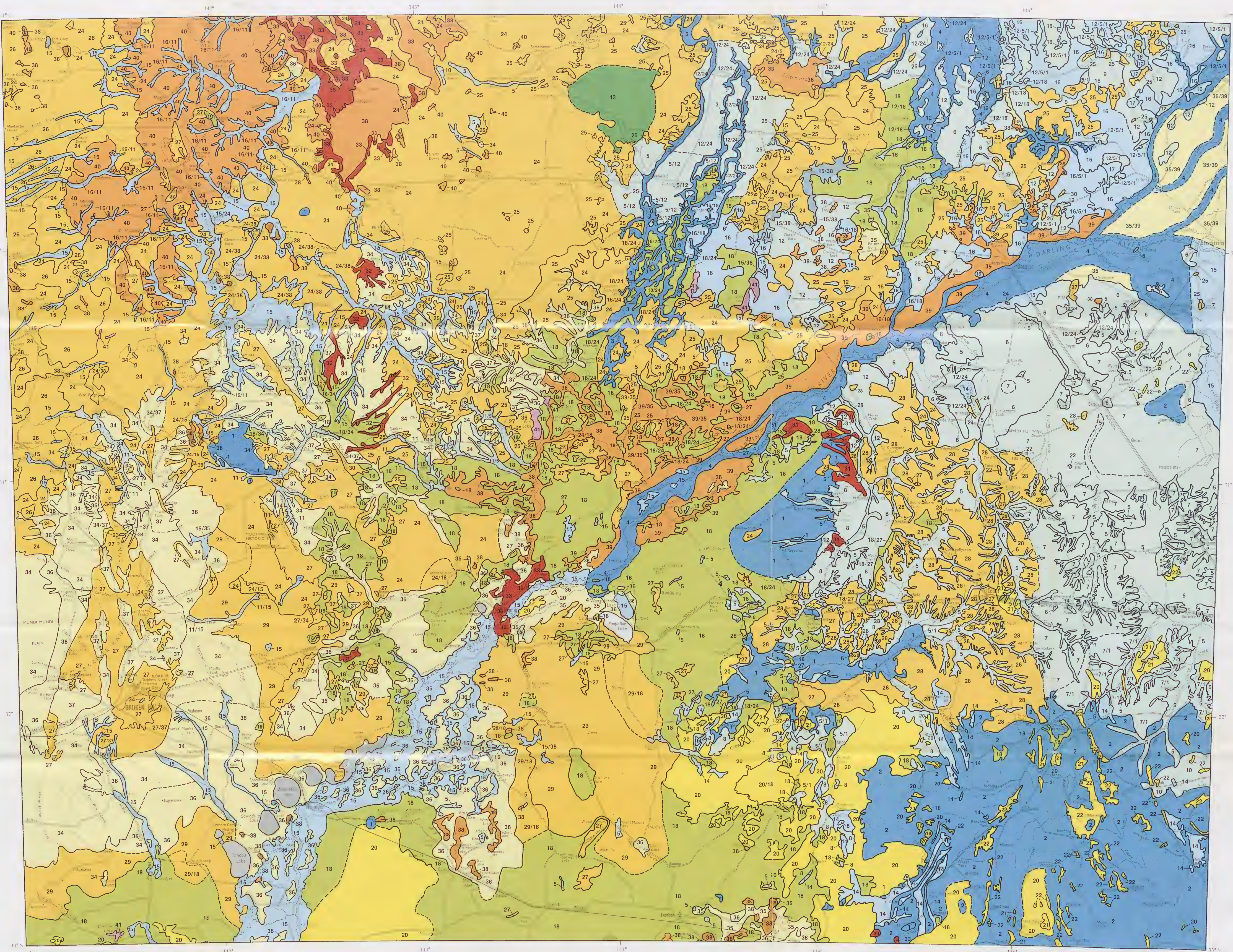
Community 19	Old Man Saltbush
Structure: low - low open shrubland #; chenopod shrubland - open chenopod shrubland ##	
Main species: <i>Atriplex nummularia</i> (Old Man Saltbush)	
Associated species: <i>Rhagodia spinescens</i> , <i>Atriplex vesicaria</i> , <i>Enchylaena tomentosa</i> , <i>Einadia nutans</i> , <i>Eucalyptus largiflorens</i> , <i>Sclerostegia tenuis</i> , other <i>Atriplex</i> spp.	
Landform: Level to depressed plains, low-lying areas and depressions.	
Soils: Grey, self-mulching, cracking clays to red duplex soils with grey and brown clays. <i>Atriplex nummularia</i> grows on a wide range of soil types and at all levels of the soil (Cunningham et al. 1981).	
Occurrence: This community occurs throughout the Hay Plain with a patchy distribution. Remnant areas occur around One Tree south of Oxley and west of Booligal. It is found in dry lakes in the north-west of the Booligal map area, particularly south of Ivanhoe. <i>Atriplex nummularia</i> often forms an understory to <i>Eucalyptus largiflorens</i> . <i>Atriplex nummularia</i> was once a dominant understory species to <i>Acacia pendula</i> (Beadle 1948, Moore 1953) but this association no longer exists within the mapped area. The mapped areas of Old Man Saltbush are remnants of once-extensive stands that have been subjected to grazing pressure, rabbit-disturbance and clearing. Many small remnants occur around homesteads and in small holding paddocks that saw little grazing. The larger remnant areas are delineated on the maps but many smaller patches exist, often consisting of only scattered individuals. <i>Maireana pyramidata</i> may occur with <i>Atriplex nummularia</i> at transition zones where higher country supporting this species grades off to low-lying areas with <i>Atriplex nummularia</i> . This is often seen in undulating country such as that around Oxley and 'Wongale' west of Gunbar.	

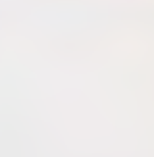
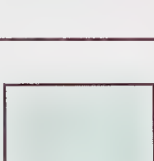
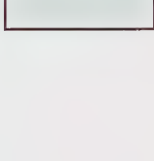
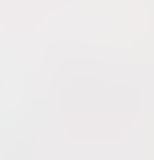
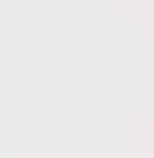
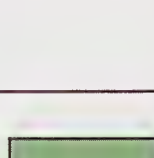
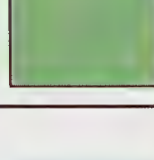
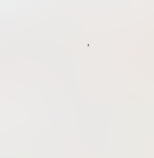
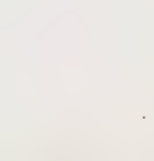
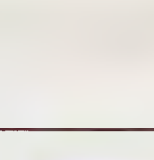
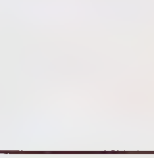
Community 21	Cotton Bush
Structure: low - low open shrubland #; chenopod shrubland - sparse chenopod shrubland ##	
Main species: <i>Maireana aphylla</i> (Cotton Bush)	
Associated Species: <i>Atriplex vesicaria</i> , <i>Sclerostegia muricata</i> , <i>Sclerostegia tricuspid</i> , <i>Nitiraria billardierei</i> , <i>Minuria cunninghamii</i> , <i>Isolaena tomentosa</i> , <i>Osteocarpum aroeratum</i> var. <i>deminuta</i> , <i>Lophorhynchus panatoides</i> , <i>Atriplex lindleyi</i> , <i>Atriplex pseudocamparipata</i> , <i>Malacocera tricornis</i> , <i>Danthonia caespitosa</i> , <i>Calceophalus sonderi</i> , <i>Sclerostegia bicornis</i> var. <i>bicornis</i> , <i>Daucus gluchidiatus</i> , <i>Colutea bipinnata</i> , <i>Rhodanthe corymbiflora</i> , <i>Rhodanthe pygmaea</i> , <i>Plantago cunninghamii</i> , <i>Podolpis muelleri</i> , <i>Colutea scabiosifolia</i> subsp. <i>scabiosifolia</i> , <i>Brachycome lineariloba</i> .	
Landform: Depressed alluvial plains, usually disturbed.	
Soils: Grey to grey-brown clays to clay-loams (Leigh & Mulham 1965).	
Occurrence: This community is widespread over the Hay Plain and has proliferated in many areas once dominated by <i>Atriplex vesicaria</i> . The largest continuous stands occur south to south-west of Hay. Dense areas occur within Willandra National Park, north-west of Hillston. <i>Maireana aphylla</i> originally occurred with <i>Atriplex vesicaria</i> in slightly depressed areas mainly in the east Darling area and excessive grazing has led to its increase with the elimination of <i>Atriplex vesicaria</i> over large areas (Beadle 1948). Shrublands dominated by <i>Nitiraria billardierei</i> , <i>Sclerostegia muricata</i> and <i>Sclerostegia tricuspid</i> indicate greater disturbance. The herbaceous layer within this community consists of short-lived perennial and annual grasses and herbs, many of them introduced, such as <i>Avena fatua</i> , <i>Hordeum leporinum</i> , <i>Lolium perenne</i> , <i>Phalaris parviflora</i> , <i>Phalaris minor</i> , <i>Bromus madritensis</i> , <i>Medicago</i> spp. and <i>Erodium</i> spp. <i>Maireana aphylla</i> and <i>Nitiraria billardierei</i> tend to occur on slightly depressed areas of the Plain as they are more flood-tolerant than <i>Atriplex vesicaria</i> (Beadle 1948). <i>Maireana aphylla</i> is often associated with medium to heavy scalding and occasional thinning or patches of remnant <i>Atriplex vesicaria</i> may be seen. Shrub cover can vary considerably in this community, ranging from dense monospecific stands to scattered individuals within a matrix comprising annual and short-lived perennial grasses.	

Community 22	Dillon Bush
Structure: low - low open shrubland #; shrubland - sparse shrubland ##	
Main species: <i>Nitiraria billardierei</i> (Dillon Bush)	
Associated Species: <i>Maireana aphylla</i> , <i>Sclerostegia muricata</i> , <i>Sclerostegia tricuspid</i> . This community occupies disturbed areas and usually comprises a high proportion of introduced and annual species. Other associated species vary depending on the composition of the original vegetation.	
Landform: Disturbed low-lying alluvial plains, dry lakebeds.	
Soils: Grey to grey-brown clay and loam soils, often saline (Cunningham et al. 1981).	
Occurrence: <i>Nitiraria billardierei</i> tends to occur in dense continuous stands in areas of high grazing pressure, particularly adjacent to riverine and box woodlands, and in previously cropped areas. Its distribution has increased markedly with the changed land use in the area since European settlement. Severe overgrazing of the original chenopod species has resulted in the establishment of Dillon Bush in areas once occupied by <i>Atriplex vesicaria</i> or <i>Atriplex nummularia</i> (Noble & Whalley 1978). Dillon Bush commonly occurs in lower densities within other shrubland and woodland communities.	

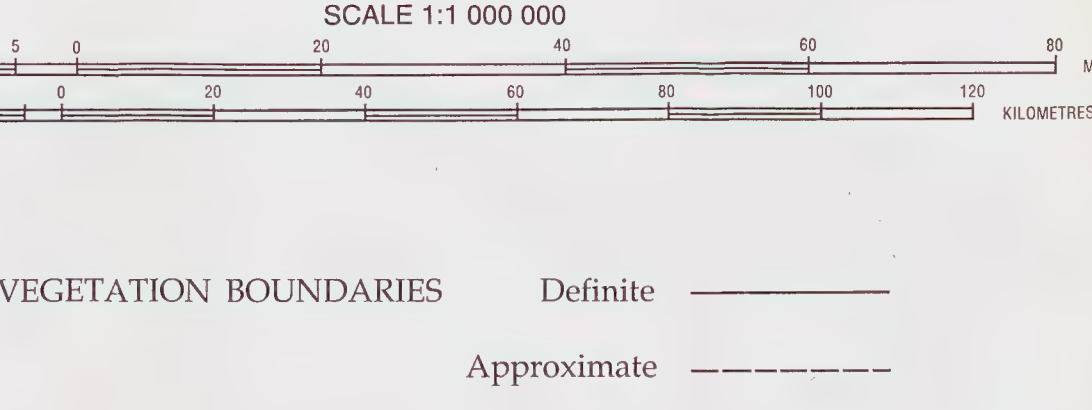
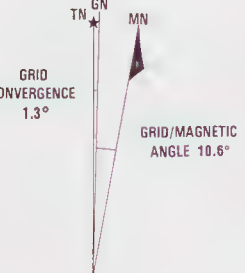
NATURAL VEGETATION OF NORTH WESTERN NEW SOUTH WALES

1 : 1 000 000



	OPEN-FOREST	
	White Cypress Pine communities (see also 14)	
	1	<i>Callitris glaucochylla</i> on sand
	2	<i>Callitris glaucochylla</i> - <i>Eucalyptus intertexta</i>
	Yapunyah communities	
	3	<i>Eucalyptus ochropholia</i>
	Coolibah communities	
	4	<i>Eucalyptus coolibah</i> subsp. <i>coolibah</i>
	WOODLAND	
	Bimble Box communities	
	5	<i>Eucalyptus populnea</i> subsp. <i>bimble</i>
	5/1	<i>Eucalyptus populnea</i> subsp. <i>bimble</i> - <i>Callitris glaucochylla</i>
	5/12	<i>Eucalyptus populnea</i> subsp. <i>bimble</i> - <i>Acacia excelsa</i>
	6	<i>Eucalyptus populnea</i> subsp. <i>bimble</i> - <i>Acacia aneura</i> - <i>Acacia</i> spp.
	7	<i>Eucalyptus populnea</i> subsp. <i>bimble</i> - <i>Eucalyptus intertexta</i>
	7/1	<i>Eucalyptus populnea</i> subsp. <i>bimble</i> - <i>Eucalyptus intertexta</i> - <i>Callitris glaucochylla</i>
	Red Box communities	
	8	<i>Eucalyptus intertexta</i> - <i>Acacia aneura</i>
	Silver-leaved Ironbark communities	
	9	<i>Eucalyptus melanophloia</i> - <i>Tridactylis mitchellii</i> var. <i>breviloba</i>
	Western Grey Box communities	
	10	<i>Eucalyptus microcarpa</i> (narrow-leaved race)
	River Red Gum communities	
	11	<i>Eucalyptus camaldulensis</i>
	11/5	<i>Eucalyptus camaldulensis</i> - <i>Eucalyptus populnea</i> subsp. <i>bimble</i>
	11/15	<i>Eucalyptus camaldulensis</i> - <i>Eucalyptus largiflorens</i>
	Ironwood communities	
	12	<i>Acacia excelsa</i>
	12/5/1	<i>Acacia excelsa</i> - <i>Eucalyptus populnea</i> subsp. <i>bimble</i> - <i>Callitris glaucochylla</i>
	12/18	<i>Acacia excelsa</i> - <i>Casuarina pauper</i> - <i>Alectryon oleifolius</i>
	OPEN-WOODLAND	
	Inland Bloodwood - Bimble Box communities	
	13	<i>Eucalyptus aff. terminalis</i> - <i>Eucalyptus populnea</i> subsp. <i>bimble</i>
	LOW OPEN-FOREST	
	Cypress Pine communities (see also 1)	
	14	<i>Callitris glaucochylla</i>
	Black Box communities	
	15	<i>Eucalyptus largiflorens</i>
	15/24	<i>Eucalyptus largiflorens</i> - <i>Acacia aneura</i>
	15/35	<i>Eucalyptus largiflorens</i> - <i>Atriplex vesicaria</i>
	15/38	<i>Eucalyptus largiflorens</i> - <i>Eragrostis australasica</i> - <i>Muehlenbeckia floruenta</i>
	Gidgee communities	
	16	<i>Acacia cambagei</i>
	16/5/1	<i>Acacia cambagei</i> - <i>Eucalyptus populnea</i> subsp. <i>bimble</i> - <i>Callitris glaucochylla</i>
	16/11	<i>Acacia cambagei</i> - <i>Eucalyptus camaldulensis</i>
	Brigalow communities	
	17	<i>Acacia harpophylla</i>
	LOW WOODLAND	
	Belah - Rosewood communities	
	18	<i>Casuarina pauper</i> - <i>Alectryon oleifolius</i>
	18/12	<i>Casuarina pauper</i> - <i>Alectryon oleifolius</i> - <i>Acacia excelsa</i>
	Inland Bloodwood - Whitewood communities	
	19	<i>Eucalyptus aff. terminalis</i> - <i>Atalaya hemiglauc</i>
	TALL SHRUBLAND	
	Mallee communities	
	20	<i>Eucalyptus socialis</i>
	20/18	<i>Eucalyptus socialis</i> - <i>Casuarina pauper</i> - <i>Alectryon oleifolius</i>
	21	<i>Eucalyptus socialis</i>
	22	<i>Eucalyptus vicina</i>
	23	<i>Eucalyptus gilii</i>
	Curly Mallee	

TALL SHRUBLAND	
Mulga communities	
24	<i>Acacia aneura</i> , on sand plain
24/5	<i>Acacia aneura</i> - <i>Eucalyptus populnea</i> subsp. <i>bimble</i>
24/15	<i>Acacia aneura</i> - <i>Eucalyptus largiflorens</i>
24/16	<i>Acacia aneura</i> - <i>Acacia cambagei</i>
24/38	<i>Acacia aneura</i> - <i>Eragrostis australasica</i> - <i>Muehlenbeckia floruenta</i>
25	<i>Acacia aneura</i> , on rocky hills
26	<i>Acacia aneura</i> - <i>Acacia ligulata</i>
26/38	<i>Acacia aneura</i> - <i>Acacia ligulata</i> - <i>Eragrostis australasica</i> - <i>Muehlenbeckia floruenta</i>
27	<i>Acacia aneura</i> - <i>Acacia tetragonophylla</i>
27/34	<i>Acacia aneura</i> - <i>Acacia tetragonophylla</i> - <i>Atriplex vesicaria</i>
27/37	<i>Acacia aneura</i> - <i>Acacia tetragonophylla</i> - <i>Maireana sedifolia</i>
28	<i>Acacia aneura</i> - <i>Acacia excelsa</i> - <i>Gelera parviflora</i>
Other Acacia Shrubland communities	
29	<i>Acacia lodieri</i>
Nelia	
29/18	<i>Acacia lodieri</i> - <i>Casuarina pauper</i> - <i>Alectryon oleifolius</i>
30	<i>Acacia divicola</i>
Bastard Mulga	
SHRUBLAND	
31	<i>Acacia ramulosa</i>
32	Horse Mulga
33	<i>Acacia cana</i>
Cabbage-tree Wattle	
Old Man Saltbush communities	
33	<i>Atriplex nummularia</i>
DWARF OPEN-SCRUB	
Saltbush and Bluebush communities	
34	<i>Atriplex vesicaria</i>
34/37	Bladder Saltbush, on downs & hills
35	<i>Atriplex vesicaria</i> - <i>Maireana sedifolia</i>
35/39	<i>Atriplex vesicaria</i>
36	Bladder Saltbush, on floodplains
37	<i>Atriplex vesicaria</i> - <i>Atriplex lappacea</i> on floodplains
38	<i>Maireana sedifolia</i>
39	Pearl Bluebush on sandplain
40	<i>Maireana sedifolia</i>
41	Pearl Bluebush on rocky areas
HERBLAND	
Grassland communities	
38	<i>Eragrostis australasica</i> - <i>Muehlenbeckia floruenta</i>
39	Canegrass - <i>Lignum</i>
39/35	<i>Astrelia lappacea</i>
40	Curly Mitchell Grass, on floodplain
41	<i>Astrelia lappacea</i> - <i>Atriplex vesicaria</i>
42	<i>Astrelia</i> spp.
43	Mitchell Grasses, on downs
SALT LAKES	
44	Various herb communities on margins



Topographic base from north-western New South Wales 1:1 000 000 map is Crown Copyright and has been reproduced with the permission of the Land Information Centre, Bathurst.

MILPARINKA	URISINO	YANTABULLA	ENNGONIA
COBHAM LAKE	WHITE CLIFFS	LOUTH	BOURKE
BROKEN HILL	WILCANNIA	BARNATO	COBAR
MENINDEE	MANARA	IVANHOE	NYMAGEE

Key to 1:250 000 map sheet areas

The map shows original vegetation cover before European settlement, as interpreted from aerial photography and field survey. Present vegetation has been affected by widespread grazing and localised clearing.

15503

NATURAL VEGETATION OF NORTH WESTERN NEW SOUTH WALES

1:1 000 000

Royal Botanic Gardens and National Herbarium

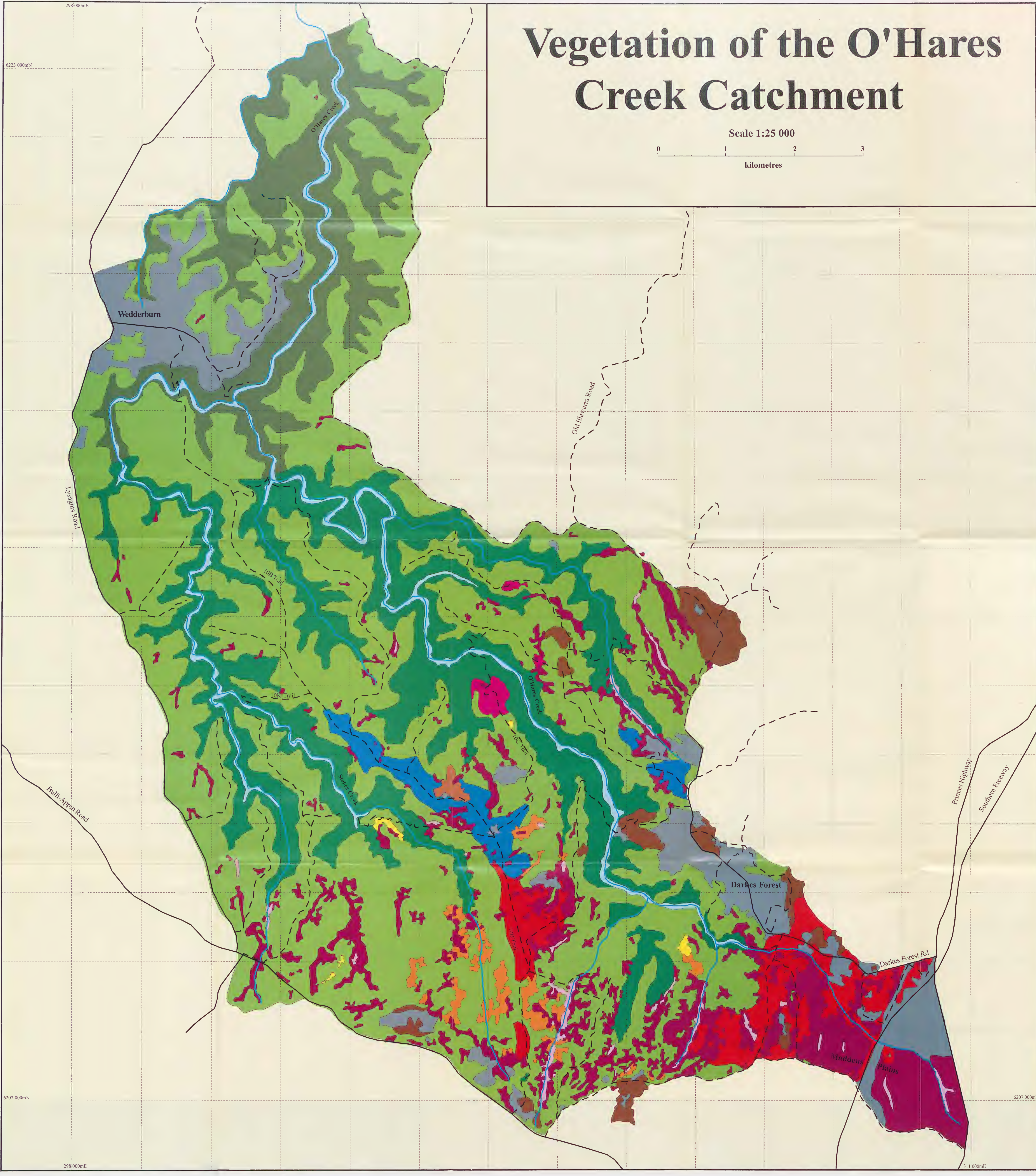
LIBRARY

Mapped by John Pickard from field traverses 1969-1981, geological maps, air photographs, photomosaics & existing vegetation maps.

Detailed descriptions of the plant communities are given in Pickard, J. & Norris, E.H. (1994) CUNNINGHAMIA Volume 3 Number 3.

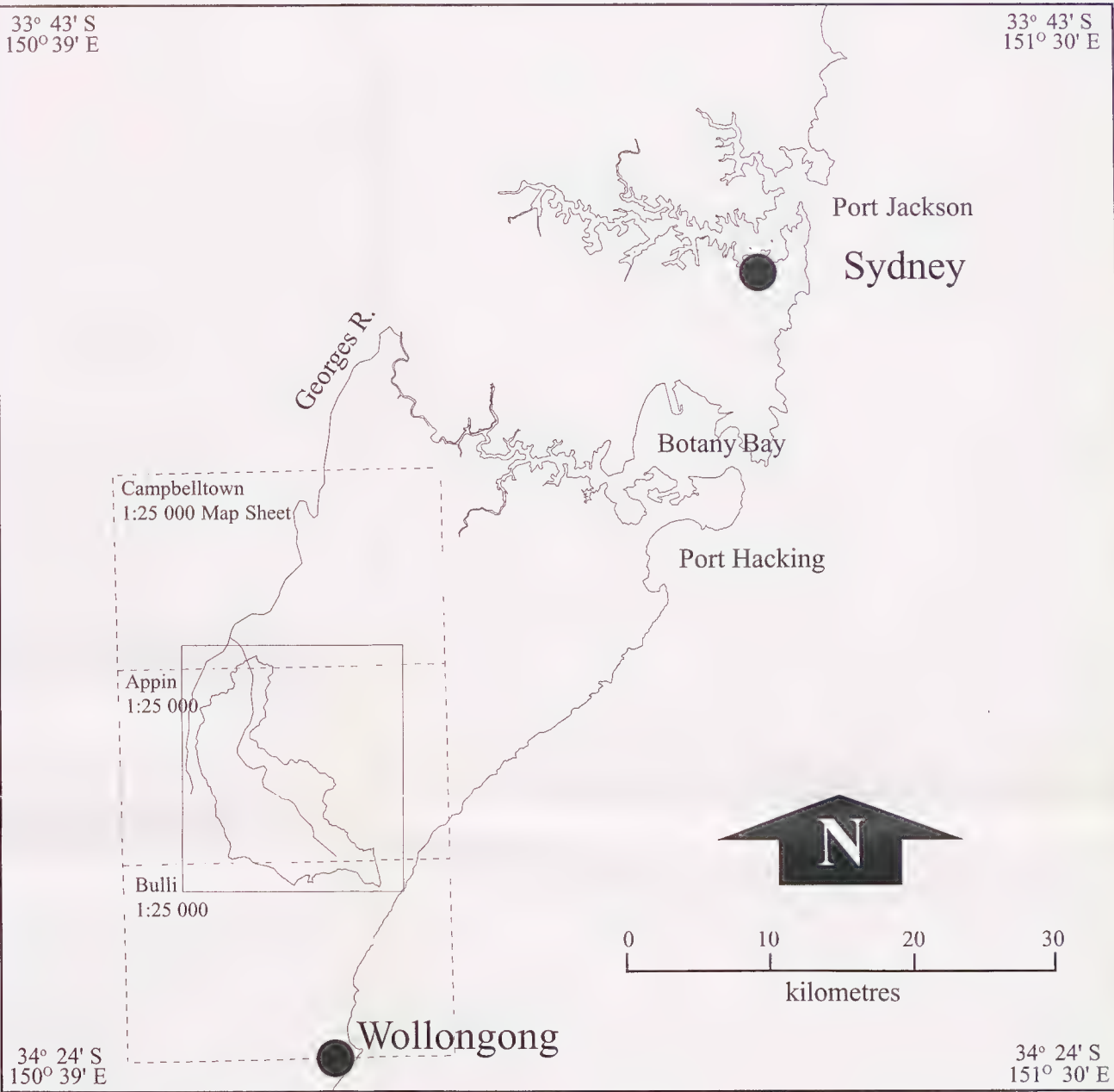
Compiled & prepared at the NATIONAL HERBARIUM OF NEW SOUTH WALES ROYAL BOTANIC GARDENS SYDNEY (1994)

Understanding the ecology of our native plants

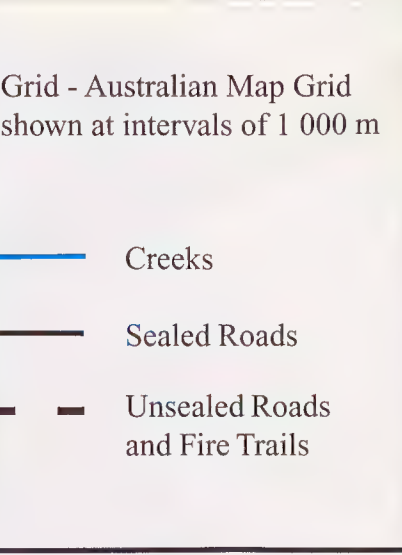


Vegetation of the O'Hares Creek Catchment

Scale 1:25 000



Community	Map Symbol	Main Species	Habitat
Shale Forest (SF)		<i>Eucalyptus globoides</i> , <i>Angophora costata</i> , <i>Eucalyptus</i> <i>piperta</i> , <i>Eucalyptus gumifera</i>	Flatridgetops capped with Hawkesbury Shale
Western Gully Forest (WGF)		<i>Eucalyptus punctata</i> , <i>Eucalyptus pilularis</i> , <i>Eucalyptus</i> <i>agglomerata</i> , <i>Angophora costata</i>	Gullies and slopes on Hawkesbury Sandstone in low rainfall areas
Eastern Gully Forest (EGF)		<i>Eucalyptus piperta</i> , <i>Angophora costata</i> , <i>Eucalyptus gumifera</i>	Gullies and slopes on Hawkesbury Sandstone in high rainfall areas
Riparian Scrub (RS)		<i>Tristania laurina</i> , <i>Tristania nerifolia</i> , <i>Leptospermum morisonii</i>	Sandy alluvium along major creek lines
Ironstone Woodland (IW)		<i>Eucalyptus sieberi</i> , <i>Eucalyptus</i> <i>racemosa</i> , <i>Eucalyptus gumifera</i>	Broad well-drained ridgetops with ironstone mantle on Hawkesbury Sandstone
Sandstone Woodland (SW)		<i>Eucalyptus oblonga</i> , <i>Eucalyptus</i> <i>gumifera</i> , <i>Eucalyptus racemosa</i> , <i>Eucalyptus sieberi</i>	Ridges and upper slopes on Hawkesbury Sandstone with well-drained soil
Heath Woodland (HW)		<i>Eucalyptus haemastoma</i> , <i>Eucalyptus gumifera</i>	Broad damp ridgetops with ironstone mantle on Hawkesbury Sandstone
Ironstone Heath (IH)		<i>Angophora hispida</i> , <i>Hakea dactyloides</i> (multi-stemmed form)	Broad damp ridgetops with ironstone mantle on Hawkesbury Sandstone
Mallee Heath (MH)		<i>Eucalyptus lucmanniana</i> , <i>Eucalyptus gumifera</i>	Stony well-drained ridgetops on Hawkesbury Sandstone
Rock Pavement Heath (RPH)		<i>Kunzea ambigua</i> , <i>Darwinia fascicularis</i>	Skeletal soils on pavements of Hawkesbury Sandstone
Banksia Thicket (BT)		<i>Banksia ericifolia</i> , <i>Hakea teretifolia</i> (single-stemmed form)	Infrequently waterlogged soils on the margins of deposits of swamp alluvium
Sedgeland-Heath (SHM) Mosaic		<i>Banksia oblongifolia</i> , <i>Hakea teretifolia</i> (multi-stemmed form)	Occasionally waterlogged soils on small areas of swamp alluvium or on upper slopes of larger swamps
Restioid Heath (RH)		<i>Sprengelia incarnata</i> , <i>Bauera microphylla</i> , <i>Symphionema paludosum</i>	Occasionally waterlogged soils on seepage slopes perched on Sandstone benches or the upper slopes of large swamps
Sedgeland (SL)		<i>Banksia robur</i> , <i>Hakea teretifolia</i> (multi-stemmed form), <i>Leptospermum juniperinum</i>	Frequently waterlogged organic soils in seepage zones on swamp alluvium
Cyperoid Heath (CH)		<i>Leptospermum juniperinum</i> , <i>Leptospermum grandifolium</i> , <i>Epacris paludosa</i> , <i>Banksia robur</i>	Heavily waterlogged peaty soils along drainage lines in large deposits of swamp alluvium
Ti-tree Thicket (TT)		<i>Leptospermum juniperinum</i> , <i>Leptospermum grandifolium</i> , <i>Epacris paludosa</i> , <i>Banksia robur</i>	Heavily waterlogged peaty soils along drainage lines in large deposits of swamp alluvium
Disturbed Land (D)		Agricultural and industrial land (in active use or abandoned and regenerating)	



The author gratefully acknowledges the assistance received in the preparation of this map from the following: G.S. Birch, State Forest of N.S.W.; Bureau of Resource Sciences, Superfine Printing.

VEGETATION
of the
O'HARES CREEK
CATCHMENT

WOLLONGONG DISTRICT
NEW SOUTH WALES

D.A. Keith

Royal Botanic Gardens
and National Herbarium

LIBRARY

Produced by M. G. Tozer,
NSW National Parks and Wildlife Service to accompany
CUNNINGHAMIA VOLUME 3 NUMBER 3, 1994.
Royal Botanic Gardens Sydney

NATIVE FLORA OF THE O'HARES
CREEK CATCHMENT

To accompany: Floristics, structure and diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney by David Keith, 1994.
Nomenclature follows Harden (1990, 1991, 1992, 1993).

PTERIDOPHYTES

ADIANTACEAE
Adiantum aethiopicum
Adiantum hispidulum
Cheilanthes distans
Cheilanthes sieberi ssp. sieberi

ASPLENIACEAE
Asplenium flabellifolium

BLECHNACEAE
Blechnum ambiguum
Blechnum cartilagineum
Blechnum nudum

CYATHEACEAE
Calochlaena dubia
Cyathea australis

DAVALLIACEAE
Davallia pycnostachya

DENNISTAEADIACEAE
Histiopteris incisa
Pteridium esculentum

GLEICHENIACEAE
Gleichenia dicarpa
Gleichenia microphylla
Gleichenia rupestris
Stichuris flabellatus

GRAMMITIDACEAE
Grammitis billiardieri

HYMENOPHYLLACEAE
Hymenophyllum cupressiforme

LINDSAEACEAE
Lindsaea linearis
Lindsaea microphylla

LYCOPODIACEAE
Lycopodium deuteroendium
Lycopodium laterale

OSMUNDACEAE
Todea barbara

POLYPODIACEAE
Platcerium bifurcatum ssp. bifurcatum

SCHIZAEACEAE
Schizaea bifida

SELAGINELLACEAE
Selaginella uliginosa

GYMNOSPERMS

CUPRESSACEAE
Callitris endlicheri
Callitris muelleri
Callitris rhomboides

DICOTYLEDONS

ACANTHACEAE
Brunoniella pumilio

APIACEAE
Actinotus helianthi
Actinotus minor
Centella asiatica
Hydrocotyle acutifolia
Hydrocotyle peduncularis
Platysace ericoides
Platysace lanceolata
Platysace linearifolia
Xanthosia dissecta
Xanthosia pilosa
(dentate form)
(dissected form)
Xanthosia tridentata

ARALIACEAE
Astrorhiza latifolia
Polyscias sambucifolia

ASCLEPIADACEAE
Marsdenia suaveolens
Tylophora barbata

ASTERACEAE
Cassinia aculeata
Cassinia areolata
Cassinia denticulata
Gnaphalium gymnocephalum
Helichrysum elatum
Helichrysum scorpioides
Lagenflera stipitata
Olearia erubescens
Olearia microphylla
Olearia viscidula
Ozothamnus diosmifolius
Senecio spargifolius
Senecio hispidulus var. hispidulus
Senecio minimus var. minimus
Vernonia cinerea var. cinerea

BAURACEAE
Bauera microphylla
Bauera rubioides

CAMPANULACEAE
Wahlenbergia gracilis

CASSYTHACEAE
Cassytha glabella
Cassytha pubescens

CASUARINACEAE
Allocasuarina distyla
Allocasuarina littoralis
Allocasuarina nana
Allocasuarina paludosa

CHLOANTHACEAE
Chloanthus stoechadis

CUNONIACEAE
Callicoma serratifolia
Ceratopetalum apetalum
Ceratopetalum gummiterum
Schizomeria ovata

DILLENIACEAE
Hibbertia densata
Hibbertia empetrifolia
Hibbertia fasciculata
Hibbertia monogyna
Hibbertia nitida
Hibbertia riparia
Hibbertia scandens
Hibbertia serpyllifolia

DROSERACEAE
Drosera binata
Drosera peltata
Drosera pygmaea
Drosera spatulata

ELAEOCARPACEAE
Elaeocarpus reticulatus

EPACRIDACEAE
Acrotiche divaricata
Astroloma humifusum
Astroloma pinifolium
Brachyoloma daphnoides var. daphnoides
Dracophyllum secundum
Epacris crassifolia
Epacris coriacea
Epacris longiflora
Epacris microphylla
Epacris obtusifolia
Epacris paludosa
Epacris pulchella
Leucopogon amplexicaulis

LEUCOPOGONACEAE
Leucopogon ericoides
Leucopogon equanatus
Leucopogon exalatus
Leucopogon lanceolatus var. lanceolatus
Leucopogon microphyllus
Leucopogon virgatus
Lissanthe strigosus
Melichrus urceolatus
Monotoca ledifolia
Monotoca scoparia
Sprengelia incarnata
Styphelia triflora
Styphelia tubiflora
Woolstia pungens

EUPHORBACEAE
Angerica xiphiolada
Berya pomaderoides
Micranthemum ericoides
Micranthemum hexandrum
Monotaxis linearis
Phyllanthus hirtellus
Poranthera corymbosa
Poranthera ericifolia
Poranthera microphylla
Pseudanthus orientalis
Pseudanthus pinuloides
Ricinocarpus pinifolius

FABACEAE
Acacia binervata
Acacia hispidula
Acacia bryoniaea
Acacia elongata
Acacia irrorata ssp. irrorata
Acacia linifolia
Acacia longifolia var. longifolia
Acacia myrtifolia
Acacia obtusifolia
Acacia rubida
Acacia stricta
Acacia suaveolens
Acacia terminalis
Acacia ulicifolia
Almalaea paludosa
Aotus ericoides
Bossiaea exata
Bossiaea heterophylla
Bossiaea obcordata
Bossiaea prostrata
Bossiaea rhombifolia ssp. rhombifolia
Daviesia acicularis
Daviesia alata
Daviesia corymbosa
Daviesia ulicifolia
Desmodium varians
Dillwynia floribunda var. floribunda
Dillwynia retorta var. retorta
Glycine clandestina
Glycine tabacina
Gompholobium glaberrimum
Gompholobium grandiflorum
Gompholobium latifolium
Gompholobium mines
Hardenbergia violacea
Hovea linearis
Kennedia prostrata var. prostrata
Kennedia rubicunda
Mirbelia rubifolia
Mirbelia speciosa
Oxylobium cordifolium
Oxylobium ilicifolium
Phyllota physicoides
Pultenaea aristata
Pultenaea blakei
Pultenaea daphnoides
Pultenaea divaricata
Pultenaea elliptica
(yellow-flowered form)
(red-flowered form)
Pultenaea flexilis
Pultenaea hispidula
Pultenaea linophylla
Pultenaea scabra var. scabra
Pultenaea stipularis
Sphaerolobium vimineum
Viminaria juncea

GERANIACEAE
Pelargonium inodorum

GOODENIACEAE
Lambertia formosa
Lomatia myricoides
Lomatia silaifolia
Persoonia lanceolata
Persoonia laurina
Persoonia levis
Persoonia linearis
Persoonia mollis ssp. nectans
Persoonia pinifolia
Petrophile pedunculata
Petrophile pulchella
Petrophile sessilis
Stenocarpus salignus
Symphionema paludosum
Telopea speciosissima
Xylomelum pyriforme

RAMUNCULACEAE
Clematis aristata

RHAMNACEAE
Cryphia ericoides
Pomaderris andromedifolia
Pomaderris intermedia
Pomaderris lanigera

LOBELIACEAE
Lobelia densata
Pratia purpurascens

LOGANIACEAE
Logania albiflora
Mitracene paludosa
Mitracene polymorpha

LORANTHACEAE
Amyena pendulum
Mellelerna eucalyptoides

MELIACEAE
Synoum glandulosum

MENYANTHACEAE
Villarsia exaltata

MORACEAE
Ficus rubiginosa

MYRSINACEAE
Rapanea variabilis

MYRTACEAE

Angophora costata
Angophora hispida
Backhousia myrtifolia
Baeckea brevifolia
Baeckea densifolia
Baeckea divaricata
Baeckea imbricata
Baeckea linifolia
Baeckea ramosissima ssp. ramosissima
Callistemon citrinus
Callistemon linearis
Calytrix tetragona
Darwinia dimorpha
Darwinia fascicularis ssp. fascicularis
Darwinia grandiflora
Eucalyptus agglomerata
Eucalyptus apiculata
Eucalyptus consideniana
Eucalyptus globulus
Eucalyptus gumifera
Eucalyptus haemastoma
Eucalyptus ligustrina
Eucalyptus leucomelanina
Eucalyptus multicaulis
Eucalyptus oblonga
Eucalyptus obtata
Eucalyptus pilularis
Eucalyptus piperita ssp. piperita
Eucalyptus punctata
Eucalyptus racemosa
Eucalyptus saligna
Eucalyptus sieberi
Eucalyptus stricta
Kunzea ambigua
Kunzea capitata
Leptospermum arachnoides
Leptospermum continentale
Leptospermum grandifolium
Leptospermum juniperinum
Leptospermum morrisoni
Leptospermum parvifolium
Leptospermum polygalifolium
Leptospermum squameum
Leptospermum trinervium
(broad-leaved form)
(narrow-leaved form)
Melaleuca densa
Melaleuca linariifolia
Melaleuca squamea
Melaleuca squarrosa
Melaleuca thymifolia
Tristania nerifolia
Tristanopsis collina
Tristanopsis laurina

OLACACEAE
Olax stricta

OLEACEAE
Nothofagus longifolia

OXALIDACEAE
Oxalis perennans

PITTOPODIACEAE
Billardiera procumbens
Billardiera scandens
Bursaria spinosa

POLYGALACEAE
Conespermum defoliatum
Conespermum ericinum
Conespermum retusum
Conespermum volubile

PROTEACEAE
Banksia cunninghamii ssp. cunninghamii
Banksia ericifolia
Banksia marginata
Banksia oblongifolia
Banksia paludosa
Banksia robur
Banksia serrata
Banksia spinulosa var. spinulosa
Conospermum ellipticum
Conospermum longifolium ssp. angustifolium
Conospermum taxifolium
Conospermum tenuifolium
(red-gummed form)
Grevillea buxifolia
Grevillea diffusa ssp. diffusa
Grevillea longifolia
Grevillea mucronulata
Grevillea oleoides
Grevillea parviflora
Grevillea sphacelata
Hakea dactyloides
(single-stemmed form)
(multi-stemmed form)
Hakea gibbosa
Hakea propinqua
Hakea salicifolia
Hakea sericea
Hakea teretifolia
(single-stemmed form)
(multi-stemmed form)
Isopogon anemifolius
Isopogon anethifolius
Lambertia formosa
Lomatia myricoides
Lomatia silaifolia
Persoonia lanceolata
Persoonia laurina
Persoonia levis
Persoonia linearis
Persoonia mollis ssp. nectans
Persoonia pinifolia
Petrophile pedunculata
Petrophile pulchella
Petrophile sessilis
Stenocarpus salignus
Symphionema paludosum
Telopea speciosissima
Xylomelum pyriforme

RAMUNCULACEAE
Clematis aristata

RHAMNACEAE
Cryphia ericoides
Pomaderris andromedifolia
Pomaderris intermedia
Pomaderris lanigera

RUBIACEAE
Galium binnifolium
Opercularia aspera
Opercularia varia
Pomax umbellata

RUTACEAE
Boronia floribunda
Boronia ledifolia
Boronia parviflora
Boronia serrulata
Correa reflexa var. reflexa
Eriostemon australis ssp. australis
Eriostemon scaber ssp. scaber
Phebalium dentatum
Phebalium dissonum
Phebalium squameosum ssp. squameosum
Zieria cymosoides
Zieria laevigata
Zieria smithii

SANTALACEAE
Chorizanthe candollei
Exocarpos cypripetiformis
Exocarpos strictus
Leptomeria acida
Santalum obtusifolium

SAPINDACEAE

Dodonaea multijuga
Dodonaea triquetra

SCROPHULARIACEAE
Euphrasia collina ssp. speciosa

STACKHOSIACEAE
Stackhousia nuda
Stackhousia viminea

STERCULIACEAE
Stereopetalum macrophyllum
Lasiopetalum ferrugineum var. ferrugineum

STYLIDIACEAE
Stylidium grammifolium
Stylidium loricifolium
Stylidium lineare
Stylidium productum

THYMELAEACEAE
Pimelea linifolia

TREMANDRACEAE
Tetratheca neglecta
Tetratheca shiresii

VIOLACEAE
Hybanthus monopetalus
Viola betonicifolia
Viola hederacea
Viola sieberiana

MONOCOTYLEDONS

AGAVACEAE
Doranthus excelsa

ANTHERACEAE
Caesia parviflora
Caesia vittata
Laxmannia gracilis
Sowerbaea juncea
Thysanotus junceifolius
Thysanotus tuberosus
Tricoryne elatior
Tricoryne simplex

ARECACEAE
Livistona australis

BLANDFORDIACEAE
Smilax glycyphylla

CENTROLEPIDACEAE
Centrolepis strigosa

COLCHICACEAE
Burchardia umbellata

CYPERACEAE
Baumea acuta
Baumea gamii
Baumea nuda
Baumea rubiginosa
Baumea teretifolia
Caustis flexuosa
Caustis pentandra
Caustis recurvata
Chorizandra cymbaria
Chorizandra sphaerocephala
Cyanochaeta diandra
Elychnia spiculata
Gahnia clarkii
Gahnia radula
Gahnia sieberiana
Gymnoschoenus sphaerocephalus
Lepidosperma filiforme
Lepidosperma flexuosa
Lepidosperma forsythii
Lepidosperma laterale
Lepidosperma limicola
Lepidosperma lineare
Lepidosperma nesi
Lepidosperma squamatum
Lepidosperma tortuosum
Lepidosperma urophorum
Lepidosperma viscidum
(red-gummed form)
(clear gummed form)
Ptilanthellium deustum
Schoenus apogon
Schoenus brevifolius
Schoenus ericetorum
Schoenus maculatus
Schoenus melanostachys
Schoenus moorei
Schoenus pachylepis
Schoenus paludosus
Schoenus turbinatus
Schoenus villosus
Tetraria capillaris
Tricostularia pauciflora

HAEMODORACEAE
Haemodorum corymbosum
Haemodorum planifolium

HYPOXIDACEAE
Hypoxis hygrometrica

IRIDACEAE
Paterosmia glabrata
Paterosmia sericea
Paterosmia sp. aff. fragilis

JUNCACEAE
Juncus planifolius

JUNCAGINACEAE
Triglochin procerus

LOMANDRACEAE
Lomandra cylindrica
Lomandra filiformis ssp. coriacea
Lomandra filiformis ssp. filiformis
Lomandra fluvialis
Lomandra glauca ssp. glauca
Lomandra gracilis
Lomandra longifolia ssp. longifolia
Lomandra multiflora
Lomandra obliqua

ORCHIDACEAE
Acanthopogon foveatus var. foveatus
Caladenia caerulea
Caladenia carnea
Caladenia major
Chiloglottis reflexa
Corybas fordhamii
Cryptostylis erecta
Cryptostylis subulata
Dendrobium linguliforme var. linguliforme
Dendrobium speciosum var. speciosum
Diplopodium punctatum
Gompholobium nubiligris
Glossodia minor
Liparis reflexa
Microtis 'sanifolia'
Orthoceras strictum
Paracaleana minor
Prasophyllum australe
Prasophyllum brevifolium
Prasophyllum elatum
Pterostylis curta
Pterostylis grandiflora
Pterostylis longifolia
Pterostylis parviflora
Thelymitra circumscripta

PHILESIACEAE

Eustrephus latifolius var. latifolius

PHORMIACEAE
Dianella caerulea
Dianella revoluta
Thelonema caespitosum
Thelonema umbellatum

POACEAE
Amphipogon strictus var. strictus
Anisopogon avenaceus
Aristida vagans
Aristida warburgii
Chionochloa pallida
Danthonia longifolia
Danthonia tenuis
Leyceuxia decipiens
Deyouzia quadrata
Dichelachne micrantha
Dichelachne rura
Echinopogon ovatus
Entolasia marginata
Entolasia stricta
Eragrostis brownii
Eragrostis glabrata
Hemarthria uncinata var. uncinata
Imperata cylindrica var. major
Microstachya stipoides var. stipoides
Oplismenus imbecillus
Panicum amabile
Phragmites australis
Pinthanthesis paradoxa
Poa labillardieri var. labillardieri
Stipa pubescens
Tetrarhena turfosa
Themeda australis

RESTIONACEAE
Empodisma minus
Hypolaena fastigiata
Leptocarpus tenax
Leprodia anarthra
Leprodia gracilis
Leprodia scariosa
Restio complanatus
Restio dimorphus
Restio fastigiatus
Restio gracilis
Restio tetraphyllus ssp. meiotachys

SMILACACEAE
Smilax glycyphylla

XANTHORHOACEAE
Xanthorrhoea arborea
Xanthorrhoea concava
Xanthorrhoea media
Xanthorrhoea resinifera (tall scape form)
Xanthorrhoea resinifera (short scape form)

XYRIDACEAE
Xyris gracilis ssp. laxa
Xyris juncea
Xyris opercularis
Xyris ustulata

NON-INDIGENOUS FLORA OF THE
O'HARES CREEK CATCHMENT

Taxa marked "+" are Australian natives unlikely to be indigenous to the area or particular habitats and proliferating in disturbed sites. Localities examined: EI - Effluent Irrigation Site, south of Darkes Forest Mine; GP - Rehabilitated Grevillea, No. 10 Fire Road; DF - Darkes Forest, farmland interface; CQ - Abandoned Clay Quarry; FT - Fire Trails (mostly 10B, 10C & No. 10); SS - Survey Sample in undisturbed vegetation; NC - North Cliff mine site.

GYMNOSPERMS

FINACEAE
Pinus radiata DF

DICOTYLEDONS

ASTERACEAE
Ageratina adenophora EI
Cirsium vulgare EI
Conyza alba EI DF FT SS
Facelis retusum GP
Gnaphalium americanum EI GP
Gnaphalium gymnocephalum EI
Hypochoeris glabra DF EI
Hypochoeris radiata EI GP DF SS
Pseudognaphalium lutes-aleum GP
Senecio madagascariensis EI DF

APIACEAE
Hydrocotyle tripartita EI

CARYOPHYLLACEAE
Polycarpon tetraphyllum GP

FABACEAE
+Acacia binervia FT
+Acacia decurrens DF
+Acacia mearnsii DF
Trifolium dubium DF
Trifolium repens EI
Ulex europaeus DF
Vicia angustifolia DF

GENTIANACEAE
Centaurium erythraeum EI

GERANIACEAE
+Geranium solanderi

ONAGRACEAE
+Epilobium hillardianum EI
Oenothera rosea EI

POLYGONACEAE
Persicaria sp. EI

ROSACEAE
Rosa 'discolor' DF SS

MONOCOTYLEDONS

CYPERACEAE
Cyperus brevifolius
Cyperus 'eragrostis'

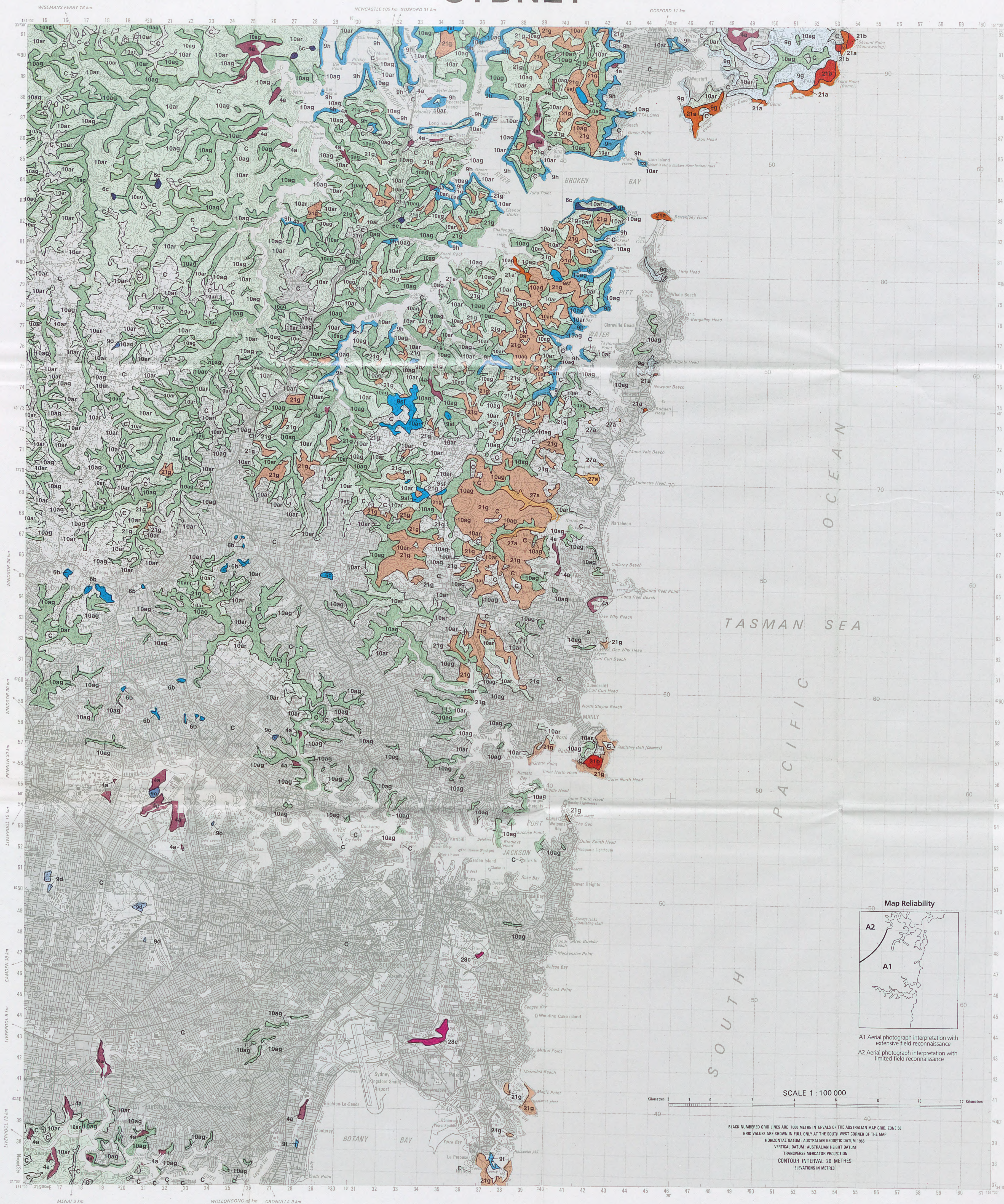
IRIDACEAE
Romulea rosea GP
Watsonia angusta DF

JUNCACEAE
Juncus articulatus EI NC
Juncus cognatus EI FT
+Juncus continuus EI FT
+Juncus planifolius EI FT
+Juncus 'polyanthus' EI

POACEAE
+Agrostis 'avenacea' EI
Andropogon virginicus EI FT DF
Cortaderia seloana EI
+Cynodon dactylon DF GP
+Danthonia longifolia FT
+Digitaria parviflora EI
Echinochloa frumentacea GP
+Eragrostis brownii FT
Eragrostis sp. EI
Holcus lanatus EI
Lolium perenne DF
Paspalum dilatatum EI
Pennisetum clandestinum DF CQ
Setaria gracilis EI
Vulpia bromioides GP

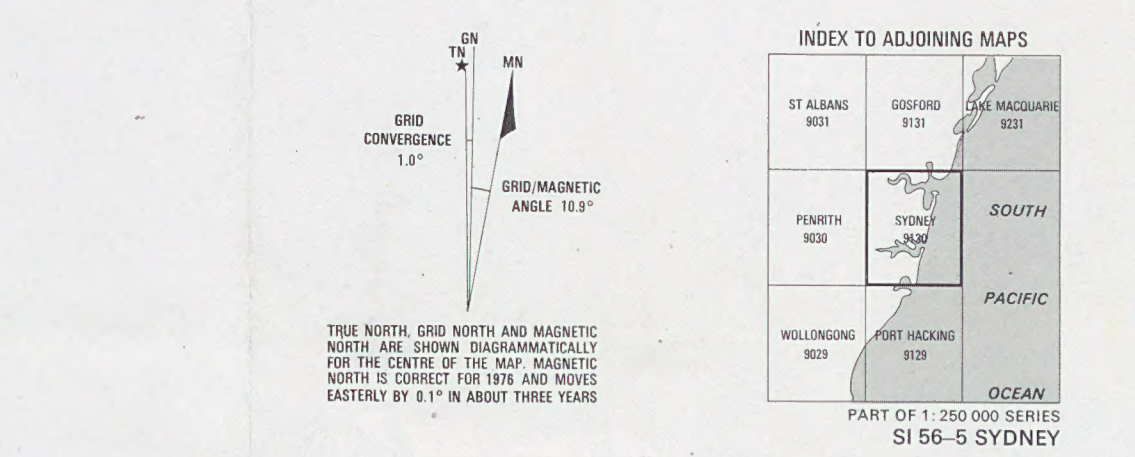
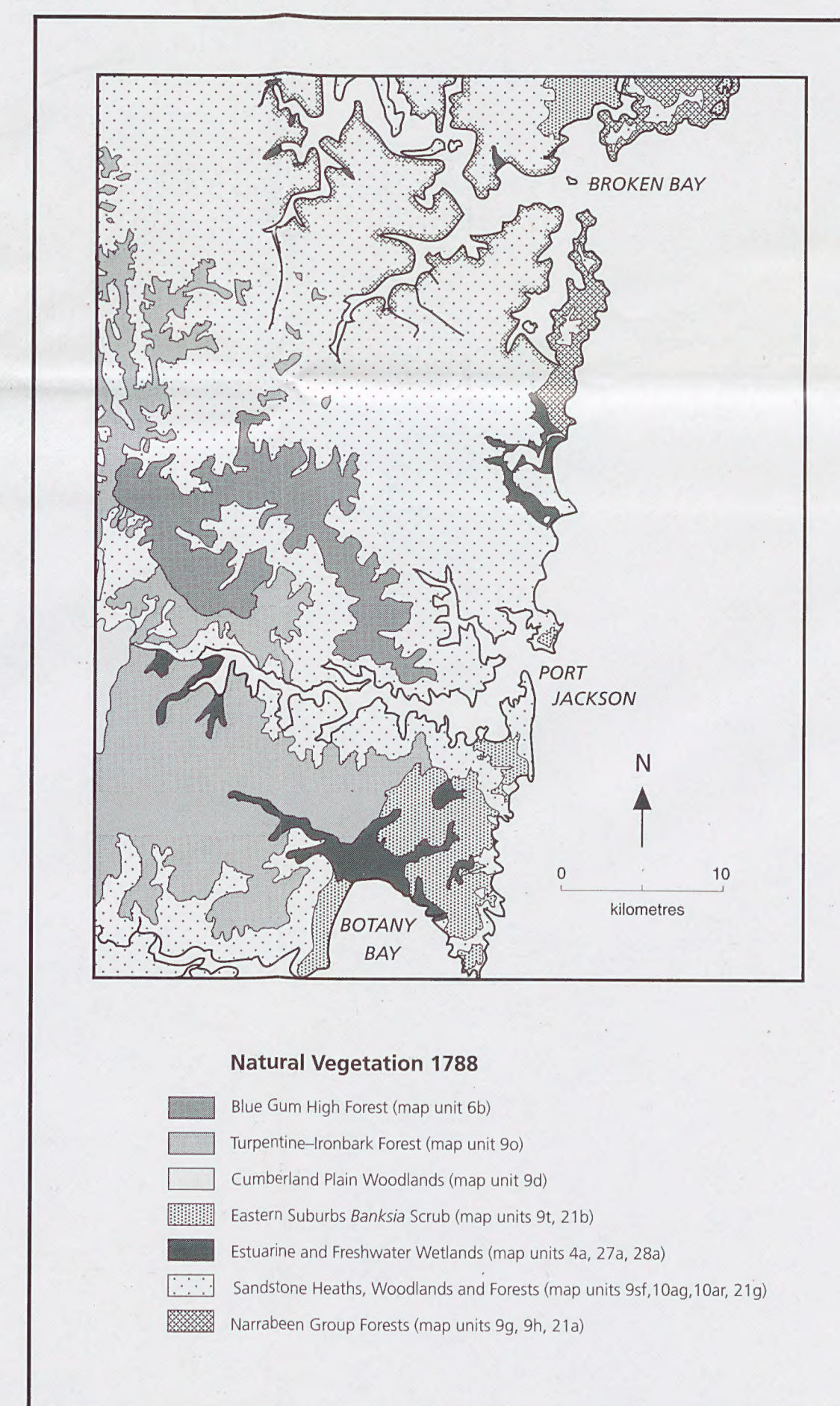
SYDNEY

1:100 000 VEGETATION SERIES



MAP UNIT DESCRIPTION				
MAP UNIT	STRUCTURE	MAIN CANOPY SPECIES	GEOLOGY	OCCURRENCE
4a	Estuarine Complex	<i>Avicennia marina</i> <i>Agiceras corniculatum</i>	Holocene alluvium	Estuarine mudflats, regular tidal inundation
	Herbland	<i>Sarcocornia quinqueflora</i> <i>Suaeda australis</i>	"	Occasional tidal inundation
	Rushland	<i>Juncus kraussii</i> <i>Phragmites australis</i>	"	Infrequent tidal inundation; brackish water
	Low open-forest	<i>Casuarina glauca</i> <i>Baumea juncea</i>	"	Poorly-drained, some saline influence
6b	Blue Gum High Forest	<i>Eucalyptus pilularis</i> <i>Eucalyptus saligna</i>	Wianamatta Shale	Broad ridges with residual shale soils
	Tall open-forest/ open-forest	"	"	North Shore to Hornsby
6c	Glen Forest	<i>Eucalyptus saligna</i>	Diatremes	Isolated valleys
	Tall open-forest	<i>Eucalyptus agglomerata</i> <i>Angophora floribunda</i>	"	"
9d	Transition Forest	<i>Eucalyptus fibrosa</i> <i>Eucalyptus moluccana</i> <i>Melaleuca decora</i>	Wianamatta Shale	Auburn
	Open-forest	"	"	"
9g	Spotted Gum - Blackbutt Forest	<i>Eucalyptus gummilera</i> <i>Eucalyptus maculata</i> <i>Eucalyptus pilularis</i>	Narrabeen Group	Bouddi Peninsula
	Open-forest	"	"	"
	Open-forest	<i>Eucalyptus maculata</i> <i>Eucalyptus paniculata</i>	"	Lower hillslopes, Warringah Peninsula
	Woodland	<i>Eucalyptus umbra</i> <i>Eucalyptus paniculata</i>	"	Exposed slopes, Bouddi Peninsula
	Open-forest	<i>Archontophoenix cunninghamiana</i>	"	Deep gullies, Bouddi Peninsula
9h	Narrabeen Slopes Forest	<i>Eucalyptus deanei</i> <i>Angophora floribunda</i>	Narrabeen Group	Lower hillslopes, Broken Bay — Hawkesbury River
	Open-forest	<i>Angophora floribunda</i> <i>Allocasuarina torulosa</i>	"	"
9i	Turpentine - Ironbark Forest	<i>Syncarpia glomulifera</i> <i>Eucalyptus paniculata</i>	Wianamatta Shale - Hawkesbury Sandstone	Inner western Sydney, lower rainfall soils between Glenorie and Ryde; often near junction with sandstone
	Open-forest	"	"	"
9sf	Duffys Forest	<i>Eucalyptus sieberi</i> <i>Eucalyptus capitellata</i> <i>Eucalyptus gummilera</i> <i>Angophora costata</i>	Wianamatta Shale - Hawkesbury Sandstone	Residual plateau remnants with ironstone gravels
	Open-forest	"	"	"
9t	Coastal Dune Forest	<i>Eucalyptus botryoides</i> <i>Eucalyptus pilularis</i> <i>Angophora costata</i>	Holocene Sand	Ramsgate La Perouse
	Open-forest	"	"	"
10ag	Sydney Sandstone Complex	<i>Eucalyptus pipera</i> <i>Angophora costata</i> <i>Eucalyptus gummilera</i>	Hawkesbury Sandstone	Sheltered hillsides, gullies
	Open-forest/ woodland	"	"	"
	Tall open-forest	<i>Eucalyptus pilularis</i> <i>Syncarpia glomulifera</i>	"	Gullies, sheltered aspects
	Closed-forest	<i>Ceratopetalum apetalum</i> <i>Tristanopsis laurina</i>	"	Sheltered gullies

MAP UNIT DESCRIPTION				
MAP UNIT	STRUCTURE	MAIN CANOPY SPECIES	GEOLOGY	OCCURRENCE
10ar	Sydney Sandstone Complex	<i>Eucalyptus gummilera</i> <i>Eucalyptus sparsifolia</i> <i>Eucalyptus racemosa</i> <i>Eucalyptus gummilera</i> <i>Angophora bakeri</i>	Hawkesbury Sandstone	Ridges, plateaus and dry, exposed hillsides
	Woodland/ low woodland	"	"	Ridges, plateaus, northwest of area
	Open-forest	<i>Banksia ericifolia</i> <i>Hakea teretifolia</i>	"	Poorly-drained soils
21a	Coastal Clay Heath	<i>Allocasuarina distyla</i>	Narrabeen Group	Long Reef to Bouddi
	Grassland	<i>Themeda australis</i>	"	"
21b	Coastal Dune Heath	<i>Banksia aemula</i>	Pleistocene sand	Coastal dunes, Bouddi, North Head, La Perouse
	Open-forest	<i>Monotoca elliptica</i> <i>Banksia integrifolia</i> <i>Leptospermum laevigatum</i>	"	"
21g	Coastal Sandstone Heath	<i>Baeckea imbricata</i>	Hawkesbury Sandstone	Shoreline heath
	Open-heath/ closed-forest	<i>Banksia ericifolia</i> <i>Darwinia fascicularis</i>	"	Coastal heath, sandy shallow soils
	Open-heath/ closed-forest	<i>Allocasuarina distyla</i> <i>Banksia ericifolia</i>	"	Widespread, often poorly-drained soils
	Open-heath	<i>Baeckea diosmifolia</i> <i>Baeckea brevifolia</i>	"	Rocky outcrop heath
	Closed-heath	<i>Hakea teretifolia</i> <i>Banksia oblongifolia</i>	"	Wet heath, poorly-drained
	Sedgeland/ shrubland	<i>Banksia robur</i> <i>Viminaria juncea</i> <i>Gymnoschoenus sphaerocephalus</i>	"	Swamps, impeded drainage
27a	Coastal Swamp Forest Complex	<i>Eucalyptus botryoides</i> <i>Eucalyptus robusta</i>	Holocene alluvium & estuarine sediment	Creekflats or impeded drainage, Warringah Peninsula
	Open-forest	"	"	"
28c	Coastal Freshwater Swamp	<i>Eleocharis sphacelata</i> <i>Baumea juncea</i> <i>Persicaria decipiens</i>	Holocene marine sand & sandy peat	Botany Swamps, Centennial Park
	Open-sedgeland	"	"	"
	Low open-forest	<i>Melaleuca quinquenervia</i>	"	"
	Open-forest	<i>Livistona australis</i>	"	"
C	Cleared	<i>Melaleuca inarifolia</i> <i>Melaleuca stypheloides</i> <i>Phragmites australis</i> <i>Typha orientalis</i>	"	"
	Open-forest	<i>Persicaria strigosa</i> <i>Blechnum carfieldii</i> <i>Triglochin procera</i> <i>Baumea juncea</i>	"	Impeded drainage
	Open-forest	"	"	"



NATURAL VEGETATION of the SYDNEY AREA

Doug Benson & Jocelyn Howell

VEGETATION OF KU-RING-GAI CHASE NATIONAL PARK AND MUOGAMARRA NATURE RESERVE included as separate map on reverse

Detailed descriptions of the plant communities are given in CUNNINGHAMIA Volume 3, Number 4, 1994 Compiled and prepared at the NATIONAL HERBARIUM OF NEW SOUTH WALES

ROYAL BOTANIC GARDENS SYDNEY 1994

Understanding the ecology of our native plants

VEGETATION OF KU-RING-GAI CHASE NATIONAL PARK AND MUOGAMARRA NATURE RESERVE

Plant communities in Ku-ring-gai Chase National Park and Muogamarra Nature Reserve

Summarised descriptions give map code, structure, habitat, geology and dominant species based on Thomas and Benson, 1985, *Vegetation survey of Ku-ring-gai Chase National Park* (Royal Botanic Gardens Sydney). Code in brackets at end shows relevant map unit for Sydney 1:100 000 map sheet.

- 1 Closed-forest**
Tristania laurina, *Ceratopetalum apetalum*
Gully Rainforest in sheltered gullies close to sea level, Hawkesbury Sandstone soils (10ag).
- 2 Low closed-forest/closed-forest with emergent trees**
Acmena smithii, *Glochidion ferdinandi*, *Livistona australis*, emergents — *Eucalyptus botryoides*, *Angophora floribunda*
Rainforest with emergent eucalypts. Sheltered slopes, mostly western Pittwater, Narrabeen Group soils (9h).
- 3 Tall open-forest/open-forest**
Eucalyptus agglomerata, *Angophora floribunda*, *Allocasuarina torulosa*
Confined to breccia in Campbells Crater (6c).
- 4 Open-forest**
Eucalyptus paniculata, *Eucalyptus umbra*, *Eucalyptus scias*, *Syncarpia glomulifera*, *Angophora floribunda*
Clay soils from weathered volcanic dyke at West Head (6c).
- 5 Open-forest**
Eucalyptus maculata, *Eucalyptus paniculata*, *Syncarpia glomulifera*, *Allocasuarina torulosa*
Western Pittwater, on Narrabeen Group shales (9g).
- 6 Open-forest**
Angophora floribunda, *Eucalyptus paniculata*, *Eucalyptus botryoides*, *Eucalyptus scias*, *Syncarpia glomulifera*, *Allocasuarina torulosa*
Sheltered slopes, western Pittwater, Narrabeen Group shales and sandstones (9h).
- 7 Open-forest**
Angophora floribunda, *Eucalyptus punctata*, *Allocasuarina torulosa*
Footslopes above saltwater estuaries and foreshores of Cowan Creek, Coal and Candle Creek, Smiths Creek and Hawkesbury River. Mostly Narrabeen Group (9h).
- 8 Open-forest**
Eucalyptus pilularis, *Eucalyptus resinifera*, *Angophora costata*, *Syncarpia glomulifera*
Upper Cockle Creek valley on Wianamatta Shale soils (9a).
- 9 Open-forest**
Eucalyptus piperita, *Angophora costata*, *Eucalyptus gummiifera*, *Eucalyptus umbra*, *Syncarpia glomulifera*
Sheltered aspects on slopes, particularly steep south-facing slopes, Hawkesbury Sandstone soils including podzols (10ag).
- 10A Open-forest**
Eucalyptus capitellata, *Eucalyptus gummiifera*, *Eucalyptus sieberi*, *Eucalyptus haemastoma*
Along Mona Vale Road on 'lateritic' soils from shale lenses now exposed as cappings on plateaus over Hawkesbury Sandstone (9sf).
- 10B Open-forest/low open-forest**
Eucalyptus sieberi, *Eucalyptus gummiifera*, *Eucalyptus sparsifolia*, *Eucalyptus haemastoma*
At Dufkys Forest on 'lateritic' soils from shale lenses now exposed as cappings on plateaus over Hawkesbury Sandstone (9sf).
- 11 Low open-forest**
Eucalyptus racemosa, *Eucalyptus gummiifera*, *Eucalyptus sparsifolia*, *Eucalyptus sieberi*
On flat ridgetops e.g. Windybanks Ridge, on Hawkesbury Sandstone with yellow-earth soils, clay sub-soils and ironstone fragments (10ar).
- 12 Low open-forest with patches of Grassland**
Allocasuarina torulosa, *Allocasuarina littoralis*, *Banksia integrifolia*, emergent trees — *Angophora costata*, *Eucalyptus botryoides*
Exposed sites on headlands with clay soils from the Narrabeen Group (21a).
- 13 Woodland**
Angophora costata, *Eucalyptus gummiifera*, *Eucalyptus umbra*, *Allocasuarina littoralis* and (west of Cowan Creek) *Eucalyptus eximia*
Moderate to steep slopes, exposed aspects on Hawkesbury Sandstone (10ar).
- 14 Low woodland**
Eucalyptus camfieldii, *Eucalyptus haemastoma*, *Eucalyptus gummiifera*
Clay soil with ironstone fragments on Hawkesbury Sandstone. Very restricted, West Head Road/Elvina Bay Track (10ar).
- 15 Low woodland/low open-woodland**
Eucalyptus gummiifera, *Eucalyptus haemastoma*, *Eucalyptus sparsifolia*, *Eucalyptus eximia* (west of Cowan Creek), *Angophora bakeri* (in Muogamarra Nature Reserve).
Low slope plateau areas — crests, spurs and upper slopes on Hawkesbury Sandstone (10ar).
- 16 Low open-woodland (mallee)**
Eucalyptus laurina
Seepage zones on upper slopes with southerly aspects on Hawkesbury Sandstone. Uncommon (10ar).
- 17 Closed scrub/scrub-heath**
Banksia ericifolia, *Hakea teretifolia*, *Allocasuarina distyla*, *Leptospermum trinervium*, *Angophora hispida*, emergents — *Eucalyptus haemastoma*, *Eucalyptus gummiifera*
Poorly-drained areas on the plateaus, low slope areas on ridges, hillsides and sandstone benches and thin skeletal soils on ridgetops. Hawkesbury Sandstone (21g).
- 18 Pockets of Heath on rocky outcrops**
Baeckea brevifolia, *Baeckea diosmifolia*, *Kunzea capitata*, *Calytrix tetragona*, *Darwinia fascicularis* subsp. *fascicularis*, *Allocasuarina distyla*
Exposed rock platforms with shallow depressions. Hawkesbury Sandstone (21g).
- 19 Tall open-scrub**
Avicennia marina, *Aegiceras corniculatum*
Mangroves along tidal watercourses and mud flats. Mainly limited to Upper Cowan Creek, Smiths Creek, Cockle Creek and Porto Bay, Kimmerakong Bay, Joe Crafts Bay and Peats Bight (4a).
- 20 Reedland/rushland and Casuarina Woodland**
Juncus kraussii, *Phragmites australis*, *Sarcocornia quinqueflora*, *Baumea juncea*, *Sporobolus virginicus*, *Casuarina glauca*
Alluvial flats associated with tidal creeks, on landward side of Mangroves (Community 19) (4a).
- 21 Sedgeland/shrubland**
Gahnia sieberiana, *Empodisma minus*, *Leptocarpus tenax*, *Schoenus brevifolius*, *Gymnoschoenus sphaerocarpus*, *Xyris operculata*, shrubs — *Banksia robur*, *Sprengelia incarnata*, *Viminaria juncea*, *Callistemon citrinus*
Areas of impeded drainage with a consistently high watertable, Hawkesbury Sandstone (21g).
- C Cleared or disturbed areas**

